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Interactive comment on "Observing the timescales of aerosol-cloud interactions in snapshot satellite images" *by* Edward Gryspeerdt et al.

Anonymous Referee #1

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Overall comment

This study makes several key contributions to our understanding of the aerosol indirect effect using ship tracks. It goes beyond classical approaches to discover that cloud responses are time dependent in ship tracks. Several conclusions are drawn from this study which will lead to advancements in the fields of satellite remote sensing and atmospheric modeling via the newly identified satellite retrieval biases in ship tracks and LWP timescale constraints. My one concern is based on the use of cloud retrievals (Nd) to detect polluted pixels comprising ship tracks. It's not clear but the use of this data appears to potentially result in fewer detected polluted pixels compared to using classical near-infrared channel data (as in Segrin et al. 2007, https://doi.org/10.1175/2007JAS2308.1). The use of Nd data for detection and analy-

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Discussion paper

sis may otherwise influence the interpretation of the results. Other than that, the paper is great and I have speckled in just a few other minor points.

Minor comments Pg3 :23 Please define "Fretchet distance" with either a reference or short description.

Pg3: 24 1,209 ship tracks are left but out of how many did you begin with? Are the decreases in this number related to the same factors outlined in figure 4?

Pg3: 25 Note, Segrin/Christensen methods use near infrared radiances to detect polluted pixels along ship tracks but figure 1 uses Nd.

Pg3: 30: "groups far from the track central location are classed as.." what does "far" mean in this context? This seems to be the method to remove nearby adjacent tracks but, how far is too far in this context? What if the track itself is very wide (up to 50 km) with some reflective edges as can happen especially in open cell cloud regimes. What is the widest tracks the algorithm can detect? I'm asking because if it fails to pick up such wide tracks in general this may offer an explanation for why the width tends to asymptote in figure 5 at great distances.

Pg5: L5-6: Based on this analysis it appears that the Nd retrieval is used to detect ship tracks since there is a lack of retrievals in the white background case considered in Fig. 2b. This would not be the case if raw near infrared reflectances were used instead for track detection. I am concerned that part of the conclusions drawn from this paper are dependent on missing retrieval data from MODIS when simply using the raw reflectances might be sufficient to detect these "missing Nd" pixels.

How is cloud fraction calculated? From the satellite retrieved Nd or from the standard collection 6 product? If it is calculated from Nd retrievals this may be problematic since it can be missing due to a variety of retrieval reasons (e.g. sun-glint) and it is used for the track detection.

What fraction of tracks are found by using the reanalysis winds where coherency in the track is lost?

Pg8: L5: “these?”

Pg8: L5-12: Durkee et al. (2000), https://doi.org/10.1175/1520-0469(2000)057<2542:CSTC>2.0.CO;2 found the average time is about 20-25 mins from which the aeorsols are emitted to intercepting the cloud layer. This is also much shorter than the average reported here. It is, thus, surprising that it can sometimes take as long as 3-4 hours (the average lifetime of a ship track) before the creation of the track. How does the author know that these tracks are not created by other nearby ships? Has this been visually verified for some of the cases? When the pollution is dispersed and form tracks much later is the track wider on average as one might expect due to dispersion? Presumably, these cases occur when the cloud layer is decoupled from the surface. Liu et al. (2000), https://doi.org/10.1175/1520-0469(2000)057<2779:MOSETA>2.0.CO;2 suggests that when the boundary layer is decoupled the emissions from ships may take considerably longer to reach cloud base. This is nonetheless a very interesting result and nicely depicts there is more variability in the 20-25 mins originally demonstrated by Durkee et al. (2000). It may be worth mentioning more prominently in the text abstract or elsewhere.

Pg9: 8. But aren’t cloud retrieved Nd required to detect ship tracks in the first place? Wouldn’t this be improved if near IR data was used instead?

Pg22: 14: “it still have less” check grammar.

Pg22: 30: One of the leading order terms in the cloud retrieval bias is the assumption on the cloud drop size distribution spectrum (Painemal and Zuidema, 2011, https://doi.org/10.1029/2011JD016155) and drizzle. Perhaps, the DSD is incorrectly assumed for ship tracks and this would offer, as you suggest, an explanation for the LWP bias close to the head of the track. I wonder, however, if there is a physical argument for decreases in LWP too? A considerable amount of latent heat is released by the rapid condensation of cloud droplets when the plume first mixes with the cloud?

Enhanced buoyancy production could lead to stronger entrainment, downdrafts and evaporation too (Cotton et al. 1995, Earth Science Reviews 39, 169–206.).

Pg23: l33: it took until near the end of the manuscript to find out the number of samples in this study this information should come much sooner – maybe add N_samples in the method section.

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