We would like to thank Michael Diamond and the two Anonymous Referees for their insightful reviews. Their corrections and suggestions improved the clarity of the manuscript significantly. Following are our point-by-point responses with the Referee comments in blue font color and italicized.

Reply to Anonymous Referee #2

The study uses geostationary satellite observations over the SE Atlantic to examine the influence of ship emissions on cloud properties. A shipping corridor is defined based on the density of shipping traffic, and cloud properties are sampled both inside the corridor and outside of it, at a safe distance from the influence of the busy shipping corridor. Clouds outside the shipping corridor are considered unperturbed, allowing the influence of ship emissions to be quantified with respect to the perturbed cloud inside the corridor using a cubic fit. The use of geostationary satellite data enables analysis across various time scales, from diurnal variations to seasonal and long-term changes. This complements previous research by Diamond et al. (2020), which used polar satellite data, providing an advancement in this area of study.

Major comments

A description of the criteria used to filter out clouds that are not liquid low-level clouds is missing. While marine clouds are the most common in the SE Atlantic region, other cloud types are also prevalent. Additionally, it is recommended to exclude cloudy pixels with uncertain retrievals based on lower thresholds of re and τ values (Sourdeval et al., 2016). Were such filters applied here? Given that marine clouds can also exist as broken cloud fields, combined with the coarser spatial resolution of SEVIRI, retrieval uncertainty is likely to be even higher than that of MODIS, for which such filters are frequently applied. Including biased retrievals can affect the averaged values, especially for Nd, due to its high sensitivity to re (Grosvenor et al., 2018). This can introduce a bias in Nd that non-linearly depends on the observed re, which varies between the corridor and the reference regions.

Sourdeval, O., C.-Labonnote, L., Baran, A. J., Mülmenstädt, J., and Brogniez, G.: A methodology for simultaneous retrieval of ice and liquid water cloud properties. Part 2: Near-global retrievals and evaluation against A-Train products, Q. J. Roy. Meteorol. Soc., 142, 3063–3081, https://doi.org/10.1002/qj.2889, 2016.

Reply: Separation of liquid from ice clouds in CLAAS-3 is performed in the retrieval of level 2 (instantaneous) cloud phase, as described in Benas et al. (2023). All cloud variables used in the present study come from level 3 data, where they are provided separately for liquid and ice clouds. Thus, successful exclusion of non-liquid clouds in our analysis depends on the performance of the cloud phase retrieval algorithm of CLAAS-3. Relevant validation results, using CALIPSO and MODIS data as reference, show overall good performance of the CLAAS-3 cloud phase algorithm, and very good agreement with the reference data over the SE Atlantic region. These results can be found in the CLAAS-3 validation report, available in Meirink et al. (2022). Regarding filtering of retrievals for thin clouds, no such threshold was applied here. Note, however, that r_e and τ values that lie outside the Nakajima-King LUT in the retrieval process are excluded from level 3 aggregations. These cases usually refer to broken clouds and cloud edges. While we acknowledge that relevant biases in the averaged values cannot be completely excluded, we would not expect variations in these biases between the corridor and adjacent regions. All these points are discussed in the revised manuscript, at the end of Sect. 2.1.

The authors chose not to include an analysis of τ because they found no response between the corridor and the reference region, likely due to the cancellation effect between the decrease in W and the increase in Nd. Given that τ is closely related to cloud albedo, does this imply there is no radiative effect *from the shipping corridor? Including a radiative perspective could enhance the study's impact by providing further insights into the potential climate effects.*

Reply: Based on another reviewer comment, an analysis of τ is now included also in the study of seasonal and diurnal cycles, since the absence of an effect in the time series averages does not exclude the possibility of seasonally or diurnally opposing positive and negative effects that average to zero but are still discernible with our method. Our findings, however, show that this is not the case: no strong indication of a corridor effect was found in either case (see Figs. S4 and S7 in the revised supplement).

τ is indeed closely related to cloud albedo, which in turn determines the cloud radiative effect. While the cloud albedo is not available in CLAAS-3, we repeated the analysis for the effective cloud albedo (CAL), which is provided in the CM SAF SurfAce Radiation DAtaset Heliosat (SARAH-3) data record. SARAH-3 consists of seven solar radiation-related parameters, retrieved based on MVIRI and SEVIRI data (Pfeifroth et al., 2024).

Results of the CAL analysis are very similar to those of τ. This is of course expected, but it is worth noting that the two variables are retrieved independently. Due to this similarity, we consider that inclusion of the CAL analysis in the study will not add further insights. The implication that the Referee suggests, however, cannot be readily made based on our results: while the cancellation effect is a possible explanation, another possibility is that, since our methodology limits the discernible effects to those manifesting as deviations from a smooth underlying background, effects of a different shape will not be detected. This possibility is included in the relevant discussion of Sect. 3.1 of the revised manuscript.

For completeness we include here plots from the CAL analysis. Note that a monthly mean diurnal cycle product is not available in SARAH-3, so the diurnal cycle analysis of CAL is omitted. Propagated uncertainties are also not included in the SARAH-3 level 3 data fields, so the corresponding uncertainty bands are also omitted from the plots below.

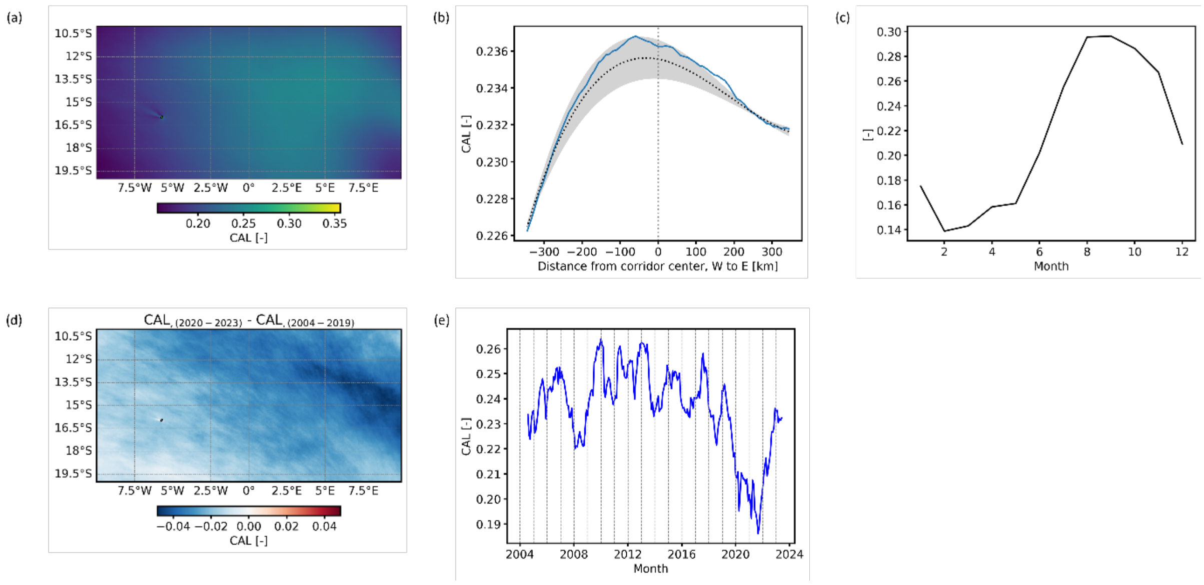

Figure 1: (a) Map of monthly time series average of CAL in 2004-2023. (b) Across-corridor average distribution of CAL (blue line); the dotted line shows the no-ship scenario and the grey band is its uncertainty. (c) Seasonal variability of the spatially averaged CAL over the study region. (d) Map of CAL differences between the periods after and before 2020. (e) Time series of monthly average CAL over the shipping corridor in 2004-2023, deseasonalized using a 12-month running average.

Pfeifroth, U., Drücke, J., Kothe, S., Trentmann, J., Schröder, M., and Hollmann, R.: SARAH-3 – satellite-based climate data records of surface solar radiation, Earth Syst. Sci. Data, 16, 5243–5265, https://doi.org/10.5194/essd-16-5243-2024, 2024.

Specific comments

Throughout the manuscript, the authors propose hypotheses for their findings that at times seem to be drawn too quickly or are overly speculative, such as in lines 220-223, 270–272 and 279-281. The authors should be more cautious when discussing findings that the current study was not specifically designed to address.

Reply: Lines 220-223: The statement that when using the 3.9 µm channel, the effect of absorbing aerosols on r_e is smaller, compared to using shorter wavelengths, is based on findings from Haywood et al. (2004). To clarify this, we moved the Haywood et al. reference after this statement. We have also rephrased the next sentence as follows: “Since the N_d retrieval depends weakly on τ and much more strongly on r_e (see e.g. equation (2) in Bennartz and Rausch, 2017), the absorbing aerosol effect on N_d is also expected to be modest compared to retrievals based on smaller wavelengths (e.g. 1.6 µm”. We hope this change also clarifies this statement and its origin.

Lines 270-272: The statement “These results indicate significant uncertainty between the two MODIS instruments”, while it refers to results from the studies mentioned before, not our results, is indeed not well supported, since other factors may also play a role in these differences. We have removed it and rephrased accordingly.

Lines 279-281: We don’t see a speculative or unsupported hypothesis here. In fact, we state that “no concrete conclusion can be drawn regarding the effect of ship emissions on f_c during the day”. The next sentence (“It can be safely concluded, however, that during night the shipping corridor exerts a negative effect on f_c”) is based on examination of difference profiles at specific night time slots, shown in supplementary Fig. S4d (Fig. S5d in the revised supplement), which includes all 24 time slots. In Fig. S6 of the revised supplement we have included all 24 time slot profiles of f_c across the corridor, with their no-ship scenarios. These plots show more clearly the corridor effect on the profiles during night, supporting our conclusion.

The differences found in the cloud properties are small, yet the axis range set in the plots make them appear more significant. This could be somewhat misleading. Why not present the results also as relative changes?

Reply: The y-axis ranges in all plots where selected to include the full range of absolute or difference values, and corresponding uncertainties, in the corridor and its surroundings. Following the Referee’s suggestion, we have included values of the average absolute and relative changes (± corresponding uncertainties) in the differences plots of Figs. 2e, 2f, 3e and 3f. We agree that inclusion of relative differences (in %) will give a better impression on the significance of these changes.

Line 172: re should be r_e.

Reply: Corrected.

Line 252-256: Can you provide a reference for why cloud thinning would lead to a smaller re? It depends on homogeneous versus inhomogeneous mixing.

Reply: The Referee is right. Cloud thinning caused by entrainment of dry air would lead to a smaller r_e under homogeneous mixing conditions. When the mixing is inhomogeneous, droplet size does not change significantly (Yeom et al. 2023).

Our interpretation of the decreasing r_e during the day stems from the fact that in adiabatic stratocumulus clouds particle size typically increases with height. Thus, when the clouds are (geometrically) thinner, the droplets at the top will be smaller, leading to a smaller retrieved r_e (Brenguier et al. 2000).

Brenguier, J.-L., Pawlowska, H., Schuller, L., Preusker, R., Fischer, J., and Fouquart, Y.: Radiative properties of boundary layer clouds: Droplet effective radius versus number concentration, J. Atmos. Sci., 57, 803-821, https://doi.org/10.1175/1520-0469(2000)057<0803:RPOBLC>2.0.CO;2, 2000.

Yeom, J. M., Helman, I., Prabhakaran, P., Anderson, J. C., Yang, F., Shaw, R. A., and Cantrell, W.: Cloud microphysical response to entrainment and mixing is locally inhomogeneous and globally homogeneous: Evidence from the lab, P. Natl. Acad. Sci. USA, 120, e2307354120, https://doi.org/10.1073/pnas.230735412, 2023.

Line 256: This sentence in not clear. Nd can be calculated from Terra, why do you say "since no Terra Nd product is available"?

Reply: Here we refer to equation (9) in Diamond et al. (2020). As also mentioned there, "no published Terra N_d product is currently available". This is still the case for the latest MODIS C061 Cloud Product. But N_d can indeed be calculated from Terra, so we have rephrased this part for clarity.

Line 274: Cloud fraction depends on the thresholds used to distinguish between cloudy and clear pixels. Perhaps the different threshold at night and day is related to the corridor effect changing between night and day?

Reply: While this is a possibility that cannot be fully excluded, we don't see why it would happen. The corridor effect is estimated based on retrievals from within the corridor and from surrounding areas. These in- and outside corridor areas will be similarly affected by different thresholds at night and day. In other words, the retrieval thresholds should affect the cloud mask differently inside and outside the corridor at night and day, in order to have an impact on the diurnal variation of the corridor effect on f_c. This appears unlikely.

It should be added here that the CLAAS-3 validation of f_c against CALIOP data results in very good scores, and the day and night retrievals appear overall consistent, with only a few irregularities in twilight conditions (defined as 75° < ϑ_0 < 95°). These details can be found in the CLAAS-3 validation report, available in https://doi.org/10.5676/EUM_SAF_CM/CLAAS/V003.

Line 311: I don't see a statistical significance test (S5 that you refer to shows maps of uncertainties). For the trend analysis related to IMO regulations, performing a significance test between the two time periods would be useful for quantifying the differences.

Reply: A statistical significance test between the two time periods was performed by comparing the absolute difference between the two periods with their combined uncertainty. It was discussed in lines 311-314 of the discussion paper, without including the relevant maps, as the Referee points. Results of the test are now included in Fig. S9 of the revised supplement, where we use a color scale for the significant cases and a grey scale for the non-significant ones. We have also revised the relevant discussion in the manuscript, adding that, while the shipping corridor is not highlighted from the surrounding regions in the statistical significance test results, the fact that it is clearly visible in the N_d and r_e differences maps in Fig. 8 is a strong indication that these differences originate in ship emission changes.

Line 313: What is CFC?

Reply: CFC is the Cloud Fractional Coverage, referred to as $f_{c,\ day}$ throughout the manuscript. We have corrected it.

Lines 360-363: This should be included earlier, in the methodology section.

Reply: Indeed. In the revised manuscript it is moved at the beginning of Sect. 2.3, and the summary and conclusions section are adjusted accordingly.