S1. Verification of precipitation within the domain

There are 5 CloudSat CPR overpasses over the course of our simulation, and the surface rain rates are plotted as a function of the latitude as they cut through our domain (Fig. S1). This shows, at least in the region of our domain during our simulation, there are some observations of precipitation. Unfortunately, none of these overpasses intersect with our exact MODIS observations of our ship tracks, due to an anomaly with CloudSat in 2018, causing it to move out of the A-train. However, these observations confirm that there is drizzle within our domain.

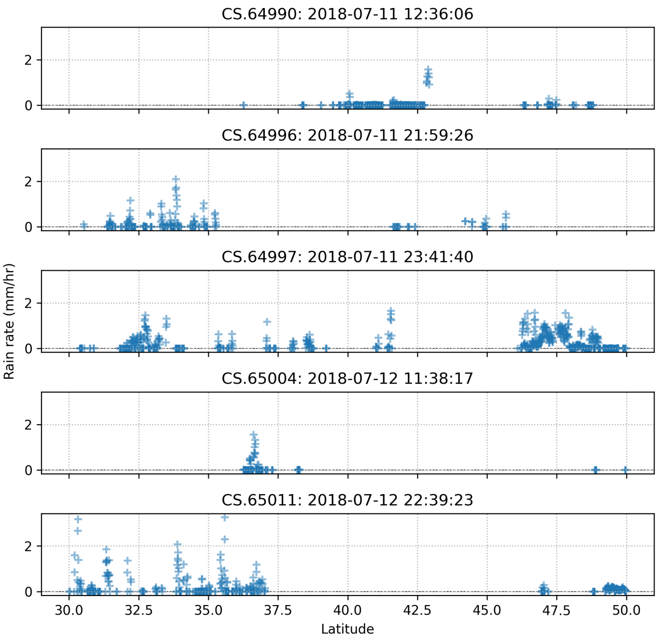

Figure S1. Observations of precipitation from CloudSat within our domain, over the course of the simulation run.

S2. Enhancements from a control cloud

In order to consider the time evolution of an aerosol perturbation to a cloud, we must consider the enhancement from some reference “unperturbed" state, such that the lifetime of the response can be measured. Due to meteorological variability over the course of 20 hours, this reference state will also be changing and therefore challenging to define.

In a model run, we can simply turn off the ship emissions and consider the clouds in the same location as the ship tracks as the unperturbed clouds, as this is exactly what the cloud would have looked like if there was no aerosol perturbation. In observations, however, we do not have a clear definition of the control region.

A benefit of ship tracks’ localised extent is that we can consider the cloud directly outside the ship tracks as the clean reference. However, this methodology has previously been revealed to introduce a bias when considering many ship tracks (Tippett et al., 2024). In the case study of this work, this bias is insignificant due to the consideration of only a few visible ship tracks in a stratocumulus region (where this bias is much smaller).

In this work, we use our model *control* run as our reference clean cloud, as it is precisely what we are trying to obtain an enhancement from, however in the observations we have no choice but to use the outside region to define our clean cloud. In Fig. S2 we compare these two methods, but applied to the model data (using both the *control* and outside region). We see that these two methods, when applied to the model data, yield similar enhancements in both N_d and LWP (to within -15% and

-10%, respectively), just with slightly more noise in the outside region method. This justifies the use of the *control* run as a means to define the unperturbed cloud in this study as the results would be equivalent if we used the outside region method.

The use of the “outside” region method only introduced a small underestimation in the enhancement in this case, compared to the *control* method, since the model background is little variability or interacting background sources. In the case that there were more ship tracks and a more complex background pattern, this uncertainty introduced would increase.

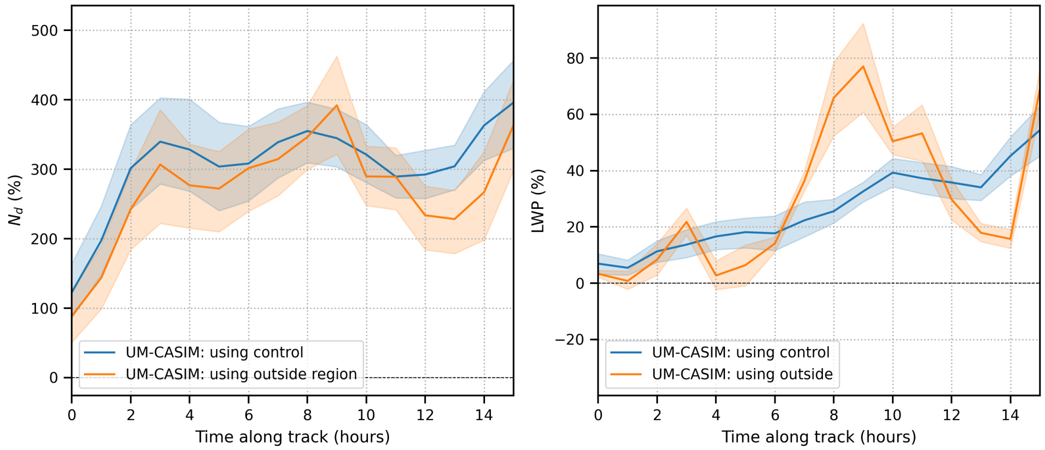

Figure S2. Enhancements from different choices of “unperturbed" cloud, for N_d (left) and LWP (right). Both methods produce similar results since the model background is clean and a good representation of the unperturbed cloud. This would not necessarily be the case if there was a more complex background with many ship tracks / background sources of aerosol.

S3. Precipitation at ship locations

In order to investigate the sensitivity of the model to the initial conditions of the cloud, before the ship sails through, we use the direction of travel of ships as a proxy for the background precipitation. Ships A-C travel away from the coast, whereas ships D and E travel from the open ocean towards California. In Fig. S3 we plot the surface rain rate at the location of the ship (in the control run so there is no effect from the ship aerosol), and demonstrate that this grouping of ships by direction of travel is a relatively good proxy for precipitating / non-precipitating conditions. We must note, however, that ships A-C are not purely non-precipitating, and do pass through some precipitating clouds towards the end of the simulation run. This explains why we do see some precipitation suppression in these tracks in Fig. E1.

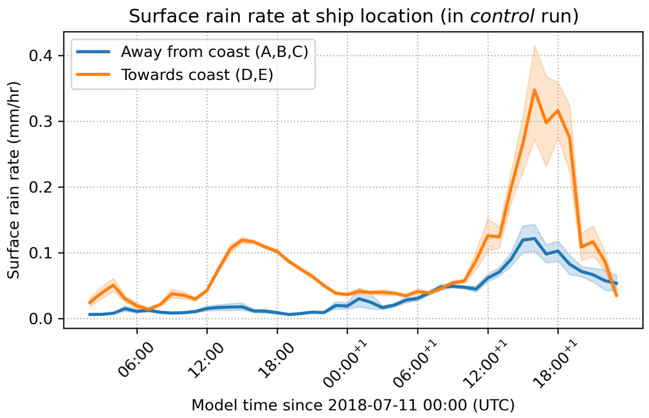

Figure S3. Surface rain rate at the ship locations, in the *control* run. Ships travelling towards the coast are travelling though clouds that are precipitating more than ships travelling away from the coast.

References

Tippett, A., Gryspeerdt, E., Manshausen, P., Stier, P., and Smith, T. W. P.: Weak liquid water path response in ship tracks, Atmospheric Chemistry and Physics, 24, 13 269–13 283, https://doi.org/10.5194/acp-24-13269-2024, publisher: Copernicus GmbH, 2024.