We appreciate the time and effort that Reviewer 2 has taken to review our manuscript and we thank them for their useful comments and suggestions on improving the paper. We have now addressed all the comments and made the necessary revisions to the manuscript. Please see our point-by-point responses below.

As a general comment, it would be good if the manuscript could present some temporal evolution and variation of the contrail radiative forcing. You have fine scale temporal detail, and you show the evaluation of the 'idealized' case, but I would like to see some use of temporal variation of the longer runs: a diurnal cycle if possible but at least an annual cycle of contrail properties and radiative forcing.

We thank the reviewer for this very good suggestion. We have now added a new analysis and figure of the annual cycle for contrail cirrus coverage and ERF to illustrate the model's behaviour. Contrail cirrus coverage is derived from the difference in total cloud cover between simulations with and without contrails, because contrail cirrus cover is not in the model output.

The following new figures and discussion have now been added at L 408-423:

'*The simulated contrail cirrus ERF exhibits a distinct seasonal cycle (Fig. 9a), reflecting the combined influence of background cloudiness and meteorology (Fig. 9c), insolation, and air traffic volume (Fig. 9b). The net ERF peaks in winter (November–January), when shortwave cooling is weakest, and approaches zero from spring to early autumn (March–September), when shortwave cooling and longwave warming are of comparable magnitudes. Previous studies have attributed the seasonal cycle of contrail cirrus ERF to variations in contrail formation and persistence, with contrails forming and persisting less frequently in summer and more frequently in winter due to changes in meteorological conditions (Chen et al., 2013; Bock and Burkhardt, 2016a). In our simulations, however, contrail cirrus coverage remains relatively modest (~0.10–0.15). However, we note that contrail cirrus coverage is defined here as the change in total cloud fraction, thereby reflecting not only the direct contrail contribution but also the changes in natural cloudiness induced by contrails. Contrail cirrus coverage is lowest in summer, despite the pronounced summer maximum in flight distance, highlighting that contrail occurrence and persistence are primarily constrained by temperature and humidity conditions.*

The seasonal cycle of total cloud fraction (Fig. 9c) is found to be closely linked to the contrail cirrus ERF. Contrails primarily enhance upper-tropospheric cloudiness between 200–300 hPa (Fig. 9d), with the largest increases in spring and late autumn to winter, coinciding with the longwave ERF peaks. By contrast, the shortwave ERF is weakest in autumn and winter (October–February). This is partly due to a relatively high amount of background low-level clouds, which leads to a 'cloud masking' effect of the additional shortwave reflection due to contrail cirrus and thereby weakens the contrail-induced shortwave cooling.'

In abstract:

'*The seasonal cycle of contrail cirrus ERF is mainly driven by the background meteorology and the natural clouds vertical structure.*'

In Conclusion:

'The simulated contrail cirrus ERF exhibits a distinct seasonal cycle, peaking in winter when shortwave cooling is weakest and approaching zero in summer when longwave warming and shortwave cooling offset each other. Our analysis also highlights the dominant role of meteorology and background clouds in controlling contrail cirrus occurrence and its radiative impact.'

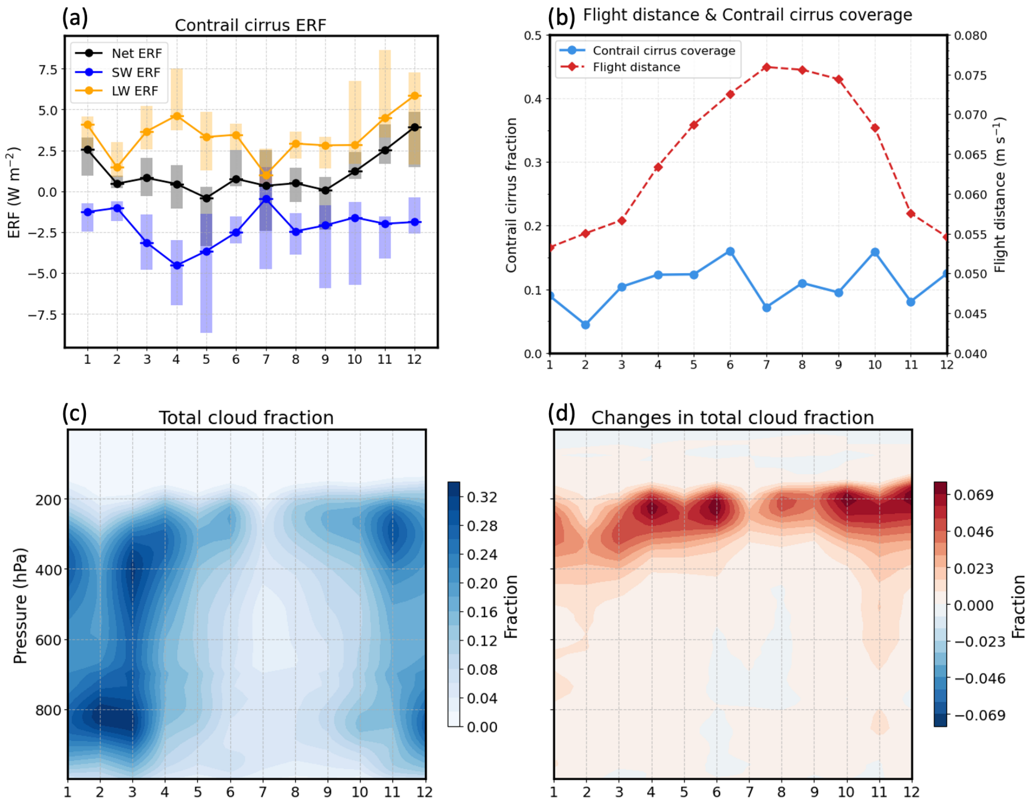

Figure 9: Annual cycles of contrail cirrus median net, shortwave, and longwave ERFs (with 10–90% ranges of daily values) (a), contrail cirrus coverage and air traffic distance flown (b), vertical distribution of area-averaged total cloud fraction in the simulations without aviation (c), and vertical distribution of area-averaged contrail-induced changes in total cloud fraction (d).

Specific Comments:

Page 4, L118: what is the depositional water in the volume? Everything above supersaturation? I guess that's what in equation 4?

Yes, that is correct. We have now clarified it as follows in the revised manuscript:

'The ice mass is calculated from both aircraft engine-emitted water vapour and depositional water (the excess water vapour above ice supersaturation) within the contrail volume.'

Page 8, L213: does that mean the area is too large?

The overestimation of contrail fraction is due to the way cloud ice is represented and cloud fraction is diagnosed in the model. We have now clarified it in the revised manuscript in L 219-227:

'*In our study, contrail fraction is defined as the difference in total cloud fraction between a simulation with contrails and one without, and it is treated in the same way as natural cloud ice. In CASIM, contrail fraction is diagnosed using the bimodal cloud fraction scheme (Van Weverberg et al., 2021), which follows the approach of Abel et al. (2017) to diagnose the ice cloud fraction. It incorporates the additional contrail ice into the grid-box subgrid distribution of humidity. As a result, contrail moisture is mixed throughout the grid-box after a single time step—much faster than in reality—leading to lower in-contrail values than observed. In addition, the conversion of cloud ice mass into cloud fraction depends on the assumed mass distribution. In this work, the initial contrail volume width is about 200 m, much smaller than the grid-box area (4 km by 4 km), introducing an overestimation to the initial contrail fraction. Higher-resolution simulations with horizontal grid spacing of around 200 m would be required to overcome this shortcoming.*'

Page 8, L216: is the cloud fraction magnitude expected just the contrail width? At 200m in a 4km grid box it;s 0.05 right?

Thank you for pointing out the need for clarification. The value is not just 0.05 in this case, as this represents only the geometric ratio of contrail width to grid-box size and neglects the contrail length. We have now edited the discussion on the initial contrail fraction to avoid potential confusions.

To clarify, in our simulations, contrail ice is added as increments to the natural cloud field and treated in the same way as background natural cloud ice. As a result, the initial contrail cirrus fraction may be overestimated due to the way cloud ice is represented and cloud fraction is diagnosed in the model. Specifically, the overestimation arises from:

1) Rapid mixing of contrail moisture into the grid-box subgrid humidity distribution.
2) The conversion of cloud ice mass into cloud fraction with the assumed mass distribution.

To illustrate point (2), we provide the plot below. Although the contrail cirrus ice water content is only of the order of 10^{-6} kg kg^{-1} (See Fig. 4b or Fig. 5b), even such small values correspond to a steep gradient in the diagnosed cloud fraction (as seen near 10^{-6} on the $\log_{10}$ ice mass axis). This indicates that small increments of contrail ice can disproportionately increase the diagnosed cloud fraction, thereby artificially amplifying cloud cover and leading to an apparent overestimation of contrail cirrus coverage.

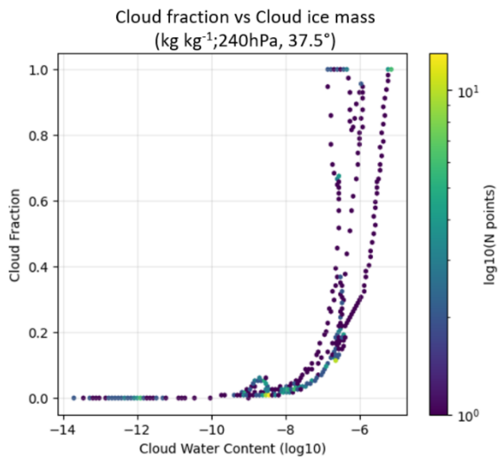

Figure 1. Relationship between cloud fraction and cloud water content shown on a $\log_{10}$ scale.

We have now update it in the revised manuscript in L 219-227:

'*In our study, contrail fraction is defined as the difference in total cloud fraction between a simulation with contrails and one without, and it is treated in the same way as natural cloud ice. In CASIM, contrail fraction is diagnosed using the bimodal cloud fraction scheme (Van Weverberg et al., 2021), which follows the approach of Abel et al. (2017) to diagnose the ice cloud fraction. It incorporates the additional contrail ice into the grid-box subgrid distribution of humidity. As a result, contrail moisture is mixed throughout the grid-box after a single time step—much faster than in reality—leading to lower in-contrail values than observed. In addition, the conversion of cloud ice mass into cloud fraction depends on the assumed mass distribution. In this work, the initial contrail volume width is about 200 m, much smaller than the grid-box area (4 km by 4 km), introducing an overestimation to the initial contrail fraction. Higher-resolution simulations with horizontal grid spacing of around 200 m would be required to overcome this shortcoming.*'

Page 9, L220: What if you just assigned the increase in cloud fraction when the contrail is initialized based on the initial width?

As mentioned above, this is not possible within the methodology of this study since the cloud fraction is diagnosed by the model based on the bimodal cloud fraction scheme (Van Weverberg et al., 2021) and cannot be directly assigned.

Page 10, L244: does this imply the density of small ice in CASIM is too low? 200 kg m-3 seems very small for small ice crystals….

We have now clarified the reason for choosing 200 kg m^{-3} for contrail ice density in the revised manuscript in L 246-254:

'*The volume-mean contrail cirrus ice particle radius (Fig. 4c) is calculated based on the equation of spherical shape ice crystals and a young contrail ice density of 200 kg m^{-3} in order* *to ensure consistency between the contrail cirrus parameterisation and the CASIM cloud microphysics scheme. An effective bulk density of 200 kg m^{-3} is used in CASIM as it is based on the mass dimension relations from Mitchell (1996) for the ice crystals with sizes of around 70 µm. Here, young-contrail properties are passed to natural clouds shortly after they are calculated by the parameterisation. From that point onward, the subsequent evolution of contrail properties—including cloud ice density—is determined by the model. Therefore, even if a larger value for contrail ice density was initially prescribed, it would only have a minor impact on the subsequent evolution of contrail cirrus. In addition, the chosen value of 200 kg m^{-3} is close to the lower end of the observed contrail ice density range of 250–400 kg m^{-3} reported in Schumann et al. (2017).'*

Page 10, L264: define QCF in figure 5b title. Is that the model variable for ice water content?

Yes, that's right - thank you for pointing it out. We have now replaced 'QCF' with 'ice water content' in the figure title.

Page 10, L270: is figure 5e just change in water vapor? Or is it change in mass above supersaturation? The latter is a function of temperature change as well, so not as clear. Suggest better to show just r water vapor change.

Figure 5e shows the change in excess water vapour above ice saturation (Δ(r−r_icesat); Fig. 2a below). To address the temperature-dependence concern, we made a plot for specific humidity change (Δr; Fig. 2b) as suggested by the reviewer.

The two fields are almost indistinguishable as a residual plot (Fig. 2c) is near zero. This reflects the small temperature perturbations from the single contrail cluster (as the temperature change shown in Fig. 5f in the manuscript) and the proximity to ice saturation (r_icesat).

To avoid redundancy, we prefer to retain the original Fig. 5e.

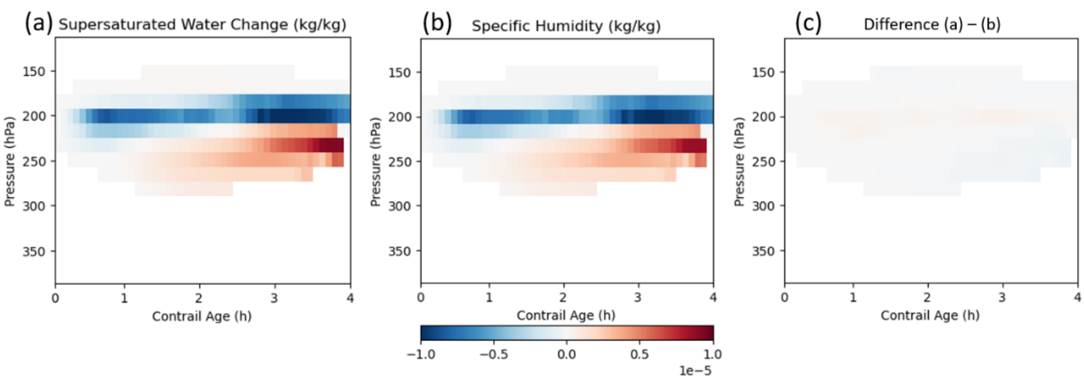

Figure 2. (a) Change in supersaturated water (kg kg^{-1}), (b) change in specific humidity (kg kg^{-1}), and (c) residual (a)−(b).

Page 12, L290: is figure 6 all 12 x 10-day periods averaged? Please state what time range is being shown.

Yes, that's correct. We have now clarified it in the figure caption as follows:

'*Figure 6: Spatial distribution of annual mean (averaged over the 10 days in all twelve months) changes in cloud (a) ice water content in kg kg^{-1}, (b) ice number concentration in kg^{-1}, and (c) ice cloud coverage.*'

Page 12, L304: This seems high given that it is near the peak of the contrail # concentration in figure 5a after 30 min.

Sorry for the confusion and thank you for pointing this out. Ice number concentration was in different units in these two figures. Fig. 6 presented the direct output from the model in units of N kg^{-1}, whereas Figure 5 (a) shows number concentration converted to N cm^{-3} (i.e. by multiplying with air density) for consistency with the units used in the in situ observations.

To avoid this confusion, we have now converted the number concentration in Fig. 6 (b) from N kg^{-1} to N cm^{-3} in the revised manuscript to allow direct comparison with Fig. 5 (a). The values in Fig. 6(b) are now more comparable to Fig. 5 (a).

Page 14, L340: Figure 8. It would be useful to note what time period this represents. An annual average? What does the annual cycle look like?

We have now clarified the time period in the caption as: '*Figure 8: Spatial distribution of annual mean (averaged over the 10 days in all twelve months) radiative forcing components …*'.

As mentioned in our response to the general comment, we have now added the annual cycle of contrail cirrus ERF in the revised manuscript.

Page 15, L379: what about the annual or diurnal cycle of contrail forcing? What frequency of AEDT inventory did you use (e.g. you can get it hourly). I assume at least monthly variation to do an annual cycle.

As we used the monthly AEDT inventory in this work, we cannot provide a full analysis of the diurnal cycle. However, as mentioned in our response to the general comment, we have now added an analysis and figure of the annual cycle of contrail cirrus ERF in the revised manuscript.