Anonymous Referee #2

I fully agree with the general comments given in the review by Darrel Baumgardner. Furthermore, the special comments given in Darrel's review cover most of the notes I made while reading the manuscript. In addition to these comments the following comments and suggestions should be addressed by the authors before submitting a revised version of the paper.

Radiation measurements: The reported radiance measurements from above and below the contrails are not very sensitive to the properties of the contrail, its age and spreading. Therefore, these measurements are presented and discussed only qualitatively in terms of "there was something". The contrail orbits and their horizontal andvertical distribution were much better located by the lidar measurements. These data were used to validate the NAME contrail location predictions as well as to monitor the spreading and fall streaks. So, I suggest to omit the radiance measurements for the sake of conciseness.

The radiance data is difficult to interpret as the thickness of the contrail cirrus was not large so not much can be gained from the measurements as noted by the reviewer. We include them here to show that there is potential that, under favourable conditions, these would be useful measurements for assessing the radiative impact of contrail induced cirrus. We shall make the following changes to the text:

Page 7844 line 13, Current text: "SWS spectra (nadir-facing geometry) for times during this Run (Fig. 8a) show clear differences for surface, cirrus and contrail measurements. Although the signals from the contrails are small compared to those from cirrus, there is clearly a measureable radiative effect."

Change to: *SWS spectra (nadir-facing geometry) for times during this Run (Fig. 8a) show clear differences in the magnitude and spectral shapefor surface, cirrus and contrail measurements.Note the data shown in Figure 8 have been normalised to 1.0, in order to show the differences in spectral shape more clearly. This obscures the observed factor of 4 increase between the contrail measurements and thick cirrus. There is clearly a significant difference in the shape of the spectra between the clear-sky, contrail cirrus and natural cirrus cases with contrail induced cirrus increasing the normalised radiances at wavelengths greater than 550nm, while thick naturally occurring cirrus has a significantly different spectral shape in normalised radiances with a reduction in radiance at wavelengths shorter than 400nm and increased radiances at wavelengths longer than 400nm. The water absorption features centred around 950, 1150 and 1400 nm also become much more evident. Potentially such differences could be used in discriminating between natural and contrail induced cirrus in future satellite algorithms."*

Page 7845, line 11, Current text: 'SWS spectra (zenith-facing geometry) for times noted here are shown in Fig. 8b. For the first sample period, the signal is very low close to the clear sky spectra. The second period has a larger effect as the contrail becomes more dispersed. There is a significant difference between the Run 1 contrail spectra and the clear sky spectra. The shift in the spectral shape is consistent with more ice crystals being present.'

Change to: *SWS spectra (zenith view) for times noted here are shown in Fig 8b (data has been normalised to 1.0). A significant (4 – 7 $Wm^{-2}\ sr^{-1}$) difference in brightness and spectral shape between the contrails and clear sky was observed. As the contrail becomes more dispersed the spectral shape shifts becoming less bright (lower signal) between ~340 and 400 nm, and more reflective (higher* *signal) between ~450 and 1300 nm. This observed shift is consistent the increasing number of ice crystals measured by CIP and CAS as the contrail disperses. Under more ideal conditions the SWS data could be used to determine the radiative impact of contrail as it ages and spreads into cirrus. The data obtained here is in agreement with previous observations that contrails have a negative radiative forcing in the shortwave.*

In the discussion section

Page 7852, line 14 – 21, Current text: ‘SWS data show that ….. and from the surface’

Change to: *SWS data show that the contrails do have a clearly measurable radiative affect (Fib. 8) particularly between ~340 and 400 nm and ~450 and 1000 nm. It is likely that the small shifts observed in the zenith data are from an increase in ice crystal concentration; however spectral shifts observed in nadir views are inconclusive. This is due to the lack of simultaneous in situ microphysical data, preventing a determination of whether the spectral shift is due to changes in crystal size/habit or changes in optical depth effects. In addition as the optical depths are low it is difficult to separate the contributions to the measured radiances from the surface and from the contrail induced cirrus. For this reason zenith viewing geometry is preferable for determining the radiative impact of contrail induced cirrus.*

Size distribution measurements: The size distributions presented in Figs. 3, 9, and 13 show that the bin between 1 and 2 um of the CAS instrument is systematically increased. This is very likely an instrument artifact which should be discussed.

The increase of the size distribution between 1 and 2 um seen in the raw data is probably due to Mie ambiguities in that size range. The peak did not vanish completely after the correction of cross-over mismatches. Thus, in the final version we combined bins in that size region to minimize the sizing uncertainties due to Mie ambiguities.

For the discussion of the differences observed in the size distribution measurements for the different contrail passes in Fig. 3, it would be useful to indicate the standard deviation on the measured bin number densities by error bars.

The standard deviation is very large for the passes where the short sharp large increases are seen, such that on the log-log scale, you can only see the upper error bar. If the log-log scale is not used, it is very difficult to see the differences in the plots. Error bars have been added for the first pass where no large increase in seen, we have shown error bars only for one pass, so as to keep the figure easy to read. The figure caption has been adjusted.

Particle habit discussion: Page 7851, lines 2 to 18. The authors report that they foundalmost no change in the ice crystal habit for the different passes and with locationof the pass within the contrail. The majority of the ice crystals detected by the CIP instrument was classified as hexagonal plates. By looking at the examples given in Figs. 6 and 10 I got the impression that most of these particles possess a "donut-like" shape which is a strong hint for out-of-focus particles. So any other particle shape especially quasi-spherical particles might result in a similar image when captured out-of-focus.

A large fraction of the contrail particles show the "donut-like" shape. If no plate-like particles were present in the contrails we would expect a smaller percentage of out-of-focus particles from previous experiences with well-defined cloud particle shapes.The issue of particles being out of focus is a problem for particles <20um, however, additional information from other probes was looked at to elucidate the shape of the smaller particles.

Richard Cotton, UK Met Office supplied information from the Small Ice Detector (SID-2) probe. We were unable to present the data in this paper due to poor sampling statistics in the size range required due to the probe being configured to sample ice particles up to 200 um, and the measured particles being at the lower limit of detection. However, from the data collected, the scattering patterns reveal patterns similar to those seen by pristine plates/columns in past studies. Higher resolution would be required to determine the exact ice crystal habits. In future studies, the use of SID-3 should allow useful size and habit information to be collected.

Furthermore, the authors cite the laboratory work by Bailey and Hallet(2004) which shows that the ice crystal habit is a function of the supersaturation with respect to ice saturation and temperature. I couldn’t find a single temperature record in the whole manuscript.

A column showing temperature has been added to Table 1 and Table 2. The temperature at which the orbits were initially formed (T ~ -60 °C), has been added to the start of section 4.1, and a sentence has been adapted to: *Figure 1 shows the flight track of the aircraft in its entirety; the temperature range for the formation and sampling of contrails was -50 to -65 °C.* The mean temperatures for data shown in figures 6, 10 and 12 are now shown in the figure caption.

Section "Extinction measurements", page 7848: I suggest to rename this section to "Determination of the extinction coefficient and ice water content" since these quantities are actually not measured.

Noted – this has been changed.

The authors note that care must be taken when comparing extinction and IWC results from different works. They argue that the determination of these quantities is dependent on the particle number concentration and the size range covered by the utilized particle sizing instruments. Since the extinction (for larger particles) is a function of the particle cross section whereas the IWC is a function of theparticle volume, the determined quantities are dependent on how the effective particle size is defined. This of course has also taken into account when comparing the results from different works.

We agree with the reviewer on this point. As noted by the first reviewer (Darrell Baumgardner), we did not state the definition of diameter used for CAS and CIP measurement in the initial submission. This has now been rectified. We are reporting area equivalent diameter.