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Atmospheric Measurement Techniques Discussions

Interactive comment on "GreenHouse gas Observations of the Stratosphere and Troposphere (GHOST): an airborne shortwave infrared spectrometer for remote sensing of greenhouse gases" *by* Neil Humpage et al.

Neil Humpage et al.

nh58@le.ac.uk

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The authors would like to thank Anonymous Referee #1 for their constructive and helpful comments on 'GreenHouse gas Observations of the Stratosphere and Troposphere (GHOST): an airborne shortwave infrared spectrometer for remote sensing of greenhouse gases' by Humpage et al. Here we respond to the specific comments in turn:

p.2,l.25: please add a reference for this requirement in the Paris Agreement.

- We have amended the reference to the Paris Agreement in the text to include the

specific sections relevant to this requirement.

p.16,l.309: "we interpolate.." Please specify interpolation method (e.g. linear).

- We use a two step interpolation: firstly, a linear interpolation is used to determine the line shape centred on each wavelength pixel; then, each pixel-specific line shape is interpolated in log(delta-wavelength) space to determine how it maps onto the neighbouring pixels. We have now added this to the manuscript.

p.17, l.341: Considerable non-linear behaviour can also be observed below 26000 counts, e.g. for band 1. In practice, do you apply the full calibration curve to convert counts to time-integrated flux, or do you use linear coefficients to approximate these curves?

- We apply a fifth-order polynomial fit to the full calibration curves, and then use these coefficients to convert our flight spectra from counts into time-integrated flux. We have amended the text slightly to make this more clear to the reader.

p.25, l.485: I suggest to replace "output of LIDORT at the height of the aircraft in the upward direction" with "upwelling radiance at the height of the aircraft"

- We agree with the referee, and have updated the wording of the text as suggested.

p.24, l.492: Please mention - in a few sentences - the most essential assumptions underlying the proxy retrieval approach.

- We have added a couple of sentences outlining the key assumptions – specifically, we assume that very similar distributions of light paths contribute to the observed spectra at the absorption wavelengths of both the gas of interest and its proxy for the total air column, and that our measurement exhibits equivalent sensitivity to both gases at the heights where the greatest deviations from the expected light path occur as a result of scattering). We have also added a couple of references for further detail if required.

p.27, l.527: Please be more specific about the applied thresholds. How were these

determined? How much data was discarded?

- We apply thresholds on the number of algorithm iterations required to converge on a solution (must be less than 7, based on using histograms of the data to identify outliers), and on the chi squared goodness-of-fit statistic (must be greater than 1, as results less than 1 are unphysical). This results in 43 out of 218 spectra along this leg of the flight being discarded. We have updated the text to describe the thresholds, including a reference justifying use of the chi-squared threshold.

p.28, l.534-l.546: A different spread in XCO2 is observed in the GHOST airborne observations compared to the CarbonTracker model and OCO-2 satellite observations. Please discuss the possible impact of the assumptions underlying the proxy retrieval approach on this observed discrepancy: how robust are these assumptions in relation to the magnitude of the observed discrepancy (6ppm versus 1.5ppm)?

- We have added the following text to the manuscript to address this comment: 'When using the proxy retrieval method, we are assuming that the two spectral ranges used are close enough in wavelength space that any systematic errors are eliminated when taking the ratio. However, this would not work (and could subsequently introduce the observed divergence in scaling factors obtained from the two spectral ranges used) in the presence of an instrumental error or effect which has sufficient wavelength dependence within the wavelength ranges observed by GHOST. Examples of these include unaccounted for straylight incident on that part of the detector, or a wavelength dependent error in the radiometric calibration.'

Please also discuss the possible impact of differences in spatial resolution / representativeness on the observed discrepancy.

- We have tried to address this comment by adding the following text to the manuscript: 'Given that OCO-2 makes observations at a higher spatial density than GHOST (because of its eight pixel cross-track imaging capability), we would expect OCO-2 data to be more representative of the variability in XCO2 along the overpass compared

with GHOST. We can infer from this that the change in discrepancy between the two datasets along the flight track is unlikely to be a result of spatial changes in XCO2 that OCO-2 might be missing as a result of mismatches in spatial resolution and location.'

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