

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.

Anonymous Referee #1

Received and published: 22 May 2018

With great interest I have read the manuscript "GreenHouse gas Observations of the Stratosphere and Troposphere (GHOST): an airborne shortwave infrared spectrometer for remote sensing of trace gases"

In this paper the authors present a new instrument (GHOST) that has been developed for remote sensing of CO₂ and CH₄ vertical columns. The optical design of the instrument (essentially a pointable telescope coupled to the GHOST spectrometer) is described in detail in the first part of the manuscript. This section is followed by a detailed description of the instrument spectral and radiometric calibration by making use

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of different light sources and optical elements (emission lamps, QTH lamps, integrating sphere). The second part of the paper describes the deployment of the GHOST instrument from the NASA Global Hawk aircraft, as part of the CAST-ATTREX campaign (Feb/Mar 2015) and includes a description of the retrieval algorithm which focuses on the CO₂ to CH₄ ratio in order to reduce the sensitivity to aerosols.

The GHOST instrument is designed for monitoring some of the most relevant atmospheric constituents and it may have an important added value in relation to the validation of current and future CO₂ and CH₄ satellite data products. The article is well-written and thorough in its description of the GHOST instrument and its optical characterization, which is the main subject of this paper. In my view the results obtained during the airborne campaign are important to demonstrate the abilities of the instrument and retrieval algorithm. The data volume is relatively small however, which limits the scope of the first results. I consider it a strong aspect of the study that the authors were able to identify a relation between oscillations in the residuals of the spectral fit and certain optical components in the telescope unit. This shows a thorough understanding of all aspects related to the instrument design and data processing and has led to an instrument improvement (replacement polariser) that was made after period considered in this paper. Altogether I recommend this paper for publication in AMT, after the following minor comments have been addressed.

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

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

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?

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”

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

p.27, l.527: Please be more specific about the applied thresholds. How were these determined? How much data was discarded?

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)?

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

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