

**AUTHOR'S RESPONSES TO AMTD INTERACTIVE COMMENT (5, C2380–C2382), :
ANONYMOUS REFEREE # 2 REVIEW**

The authors wish to thank the reviewer for their thorough reading of the discussion paper, and subsequent extensive corrections and suggestions. We consider the modifications applied have helped to produce a much improved manuscript. We reply to their points below with the referee's comments in bold, and our responses in italics.

This is a nice expose of the retrievals of formaldehyde columns, including a detailed discussion of the relative importance of errors that contribute to the total column error. I have some suggestions and comments that I would like the authors to consider but I recommend the paper be published.

The abstract should summarize the impact of different errors by defining impact.

To define impact, we have removed "...tend to have the largest impact on the fit residuals." and replaced with "...tend to offer the largest modulations of retrieved slant column magnitude and fit quality"

Abstract and elsewhere: I felt the message about the reference sector method was a little unwise. This approach is only strictly valid for systematic error sources that are geographically and temporally invariant.

We are indeed correcting for systematic error sources - Pacific biases contain systematic components, as well as random components (e.g. Ozone interference at higher latitudes) and undetermined components. As we apply the reference sector method on a latitudinal basis, over the globe we see the correction as being geographically invariant. Similarly, the correction is performed daily, and so is also invariant in time.

Introduction: Provide the reader with an idea of the background column due to methane oxidation and that will help emphasize the importance of the continental enhancement.

Typical magnitude of background HCHO column included in introduction.

Introduction: The paper needs a reference for large HCHO enhancements over localized VOC sources. Plenty of aircraft campaigns that show this feature.

References added for each of the HCHO sources mentioned.

Introduction: Tell the reader the importance of OH and photolysis as sinks of HCHO.

Amended the introduction to emphasise this "... CH₂O has a short atmospheric lifetime of only a few hours, with atmospheric sinks primarily determined by photolysis and reaction rates against the hydroxyl radical (OH) (Cooke et al., 2010). Consequently, determination of CH₂O magnitudes and distributions are of major importance in interpreting the OH chain, particularly for highly reactive tropical ecosystems (Singh et al., 1995). The molecule's rapid reaction time makes it a suitable proxy..."

Introduction: Despite HCHOs relatively high... Relative to what?

Removed 'relatively'

Introduction: This reader appreciates the comprehensive nature of the referencing but the Eisinger et al reference is likely insufficient for a peer-review journal. The Thomas et al paper was a qualitative study over a limited biomass burning feature.

Agreed, Eisinger reference removed from the manuscript.

Introduction: Line 17: its?

Amended

Introduction: I am being perhaps overly picky but I would question use of some words, e.g., engendering, dichotomy (section 3.1); in some instances they are inappropriate.

'Dichotomy' replaced with 'relationship', 'engendering' replaced with 'resulting in'

Be consistent with words, e.g., on-board and onboard, HCHO and CH₂O (text and figures).

Replaced *HCHO* with *CH₂O* throughout the manuscript for consistency with other chemical notation (e.g. *O₃*, *O₄*) and between text and figures.

Typo should be MetOp not METOP.

Amended

Section 3: I think the paper would benefit from a simple table that quantified the relative importance of each source considered in the paper. I suggest the authors consider a synthetic case in which they know the truth, impose realistic sources of error, and quantify the errors (retrieval minus truth).

Synthetic spectra would be useful in certain instances, however the author's feel that in the case of GOME-2, possessing a multitude of instrumental issues (particularly in the CH₂O fit range - see De Smedt et al., (2012)), realistic synthetic spectra would be extremely difficult to model when taking onboard undersampling, scan bias and linear offset issues to name but a few. We also note comparable papers on retrieval characterisation (albeit from ground based DOAS spectrometers) such as Aliwell et al., (2002), and Pinardi et al., (2012) make use of real spectra for these reasons. Whilst synthetic spectra would be useful in certain instances – fit range testing for example – we feel it's application to the GOME-2 case would be limited.

Section 3.4.2. Quantify minute

'Minute' changed to small, and typical calculated undersampling shift value of 0.007 nm given.

Section 4.5: 4x5 lat/lon?

Amended

Section 4.4: this section would benefit from a brief discussion of the competing aerosol and cloud processes that could lead to the same result regarding columns over places like the Amazon basin.

Amended section 4.4 to include information on this: "Interaction between cloud and aerosol which exist over the study regions, and their representation by the AMF, may play a large part in spurious slant to vertical column conversions above certain cloud thresholds (Boersma et al., 2004). Biomass burning, often encountered in tropical ecosystems such as the Amazon, encourages pyroconvection, with associated uplift of aerosol high into the troposphere (~ 5 km) (Gonzi and Palmer, 2010). Aerosol at these heights can shield incoming radiation from underlying CH₂O, effecting a decrease in the AMF and subsequent increase in CH₂O vertical columns. High clouds also affect the AMF in the same way, but possibly to a greater extent owing to their increased albedo compared to aerosols. Considering biomass burning cases, these two processes are likely to act in concert, with a greater number of aerosol molecules providing cloud formation nuclei."

Figure 6 captions has an odd start.

Replaced first sentence of caption with "Scan number 3107 (orbit 4176) repeatedly retrieved with the reference settings, adjusting the low and high temperatures of the orthogonalised O₃ absorption spectra in increments of 0.5 K".

References:

Aliwell et al., Analysis for BrO in zenith-sky spectra: An intercomparison exercise for analysis improvement. Journal of Geophysical Research D: Atmospheres, 107(14):1011020, 2002.

De Smedt et al., Improved retrieval of global tropospheric formaldehyde columns from GOME-2/MetOp-A addressing noise reduction and instrumental degradation issues. Atmospheric Measurement Techniques Discussions, 5(4):55715616, 2012.

Pinardi et al., MAXDOAS formaldehyde slant column measurements during CINDI: intercomparison and analysis improvement. Atmospheric Measurement Techniques Discussions, 5(5):66796732, 2012.