

Interactive comment on “Profiling tropospheric CO₂ using the Aura TES and TCCON instruments” by L. Kuai et al.

Anonymous Referee #1

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This manuscript describes the retrieval of CO₂ using measurements from the TES instrument on the Aura satellite and ground-based remote sensing from TCCON. The combination of TIR and NIR wavelengths provides a ‘profile’ with two pieces of vertical information. The benefit gained by separating the vertical column is the ability to isolate the boundary layer from the free troposphere, since the boundary layer is where surface sources and sinks actually interact with the atmosphere, and thus of greater interest than a column-average.

The topic of this manuscript is appropriate for AMT and the work presents a significant contribution to the field. The quality of the scientific results is good. The overall presentation quality is good, but one weakness was the choice of citations, which were

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often not appropriate; however this can be improved based on the comments below, and does not impact or reflect on the scientific findings.

The work is original and also long overdue. As stated in the manuscript, the concept of combining NIR and TIR observations to derive vertical information on atmospheric CO₂ was described in Christi and Stephens (2004), but to my knowledge, the present work is the first study to implement the concept using real remote sensing observations. At the close of the introduction the authors state “We do not use the direct profiling approach discussed in Christi and Stephens (2004) because we found that spectroscopic errors and sampling error due to poor co-location of the NIR and IR data currently result in unphysical retrieved CO₂ profiles. Instead we simply subtract free tropospheric column estimates from total column estimates in order to quantify lower tropospheric CO₂ column amounts.” I would have liked to see more details and clarification and perhaps an example illustrating why the joint NIR+TIR retrieval did not work, since if there are any factors that will prevent the approach from working with real data, this would be an important finding for future missions planning to apply the concept, or perhaps even upcoming work combining GOSAT NIR+TIR.

Specific Comments and Technical Corrections

P4496, line 4-5: “model transport errors” should simply be “model transport”

P4496, line 23: “precisions” should be “precision”

P4497, line 1: The paper should do a better job of distinguishing between ground-based in situ and remote sensing observations.

P4497, line 24: The authors fail to mention SCIAMACHY NIR observations here, with the statement “starting with GOSAT”, although they do mention SCIAMACHY observations on page 4510. Also, GOSAT is the satellite name, TANSO-FTS is the instrument name.

P4497, line 24-29: These citations are poorly chosen. Crisp et al. 2004 should not be

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cited for GOSAT since it is about OCO with no mention of GOSAT. Crisp et al. 2012 AMT would be appropriate. Yoshida et al. 2009 is not listed in the references, but the authors probably mean Yoshida et al. 2011 AMT, which needs to be added. Velazco et al. 2011 is a CarbonSat constellation paper, Bovensmann et al. 2010 is the original CarbonSat paper. Yoshida et al. and Yokota et al. 2009 are not appropriate citations for GOSAT-2 since they do not mention the successor mission, but at present I believe only presentations for this upcoming mission are available. The OCO-2 launch is scheduled for July 2015, so "later this decade" is a poor choice of words, since it is less than 2 years away. "The near future" is a poor choice of words for CarbonSat and GOSAT-2. GOSAT-2 will likely launch later this decade, possibly as early as 2017. CarbonSat is still in competition, and if selected will launch no earlier than 2019. However, none of these projected launch dates are firm, since delays for various reasons are inevitable.

P4497, line 29 to p4498, line 1: A distinction between ground-based in situ and remote sensing should be made here. It might also be worth mentioning (somewhere) that TCCON ground-based remote sensing facilitates comparisons between in situ measurements and satellites.

P4498, line 19: TCCON is not an instrument, it is a network of instruments.

P4498, line 22: "recorded spectral region range" can simply be replaced with "recorded spectra"

P4499, line 13: Surprisingly the authors do not cite their own paper Kuai et al. 2012, "Vertically constrained CO₂ retrievals from TCCON measurements", JQSRT.

P4498, line 23-26: (Beer et al. 2001) should come after "1 TES measurement every 100 km approximately" not after a reference to GEOS-Chem. Similarly Kulawik et al. (2010) should come earlier in the paragraph. I am not sure if Kulawik et al. 2011 (AGU presentation) is really needed or if this should just be replaced with Kulawik et al. 2012 ACPD?

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P4500, line 9: I would have expected there to be a better citation than the Kulawik et al, papers for SGP-ARM data.

P4502, line 1: Do the authors have a citation for the 1% bias for the O₂ A-Band? Various retrieval algorithms (ACOS, NIES, RemoteC, ...) are applying different correction factors.

P4502: A brief description of the GEOS-Chem CO₂ modeling setup is needed to clarify the version number, horizontal and vertical grids, standard fluxes or others, and whether the model runs were evaluated using some in situ data.

P4503: The term "jack-knifing" is not clear to me, so I think other readers would benefit from a brief explanation at least, but as mentioned above, more details on obstacles to combining NIR+TIR here could potentially be very helpful for the CO₂ retrieval community.

P4506, line 10: "(or)" should be removed

P4508, line 14 and P4514, line 12-13: grammar issues

P4515, line 7: Is the assumption of free-tropospheric CO₂ being well-mixed valid over land? Wofsy et al. (2011) HIPPO measurements are predominantly over the Pacific.

Table 1 caption: "imperial" should be "empirical".

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