

## ***Interactive comment on “Methane profiles from GOSAT thermal infrared spectra” by Arno de Lange and Jochen Landgraf***

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This paper describes an approach for retrieval and validation of methane profiles from GOSAT thermal infrared radiances. The authors develop a correction to the radiances, based on radiance closure between GOSAT measured radiances and forward-modeled radiances using HIPPO aircraft profile measurements as input. Using a separate validation set, the authors show that this correction significantly mitigates the high bias in upper tropospheric methane retrievals observed in this work. (As this paper points out, a similar bias has also been observed in other nadir thermal infrared methane retrievals.)

In my mind, there are two particular strong points of interest in this paper. One is

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the correction approach, which could be readily applied to methane (and potentially to other retrievals of well-mixed gases) from other nadir-sounding thermal infrared instruments, such as TES, AIRS, CrIS and IASI. The authors may be interested to know that a similar approach, using empirical orthogonal functions is currently being applied within the OCO-2 Level 2 algorithm (see comments below). The other point of interest is the use of model profiles, scaled to TCCON total column estimates, for validation. This approach allows proper consideration of the vertical sensitivity of the thermal infrared retrievals in the comparison, while providing a relatively large number of samples for validation, with samples that are independent of the measurements used to develop the correction. The scope is well-suited to AMT, the work presented represents an interesting contribution to the field and the paper should be published after minor revisions. Minor comments, suggestions and questions for the authors are listed below.

In general: How good are the MACC CH<sub>4</sub> profiles? Can the authors provide any references to model validation? Are the profile comparisons sensitive to uncertainties in the model representation of the stratosphere?

Abstract, lines 14-15: “This filter...is consistent with the cloud filter based on the GOSAT-SWIR measurements, despite the fact that the TIR-filter is less stringent”. I was not clear on what this means. When you say the filter is consistent, do you mean that the bias in the retrieved profile does not change according to which filter is used? Consider changing the wording to say that the bias (rather than the filter) is consistent?

Page 2, lines 1-12: Please also list the Cross-track Infrared Sounder (CrIS). There is a CrIS flying on the Suomi-NPP satellite, launched in 2011, and there will be follow-on instruments on the JPSS satellite series. I am not aware of a publication on CrIS CH<sub>4</sub> retrievals to date, but there are definitely people working on those.

Page 2, lines 23-29: This discussion of previous work is a little hard to follow and would benefit from some re-wording for clarification of various points. Papers from Saitoh (2012) and Holl (2016) cannot both present “first results”. It would be helpful to

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clarify that the Saitoh (2012), Holl (2016) and Zhou (2016) papers all discuss GOSAT TIR results from the same algorithm, and that algorithm is different from the one that you are using here. (Degree of signal should be degrees of freedom for signal?) When you say that the degrees of freedom for signal are significantly lower than 1, are you referring to the degrees of freedom for signal in that other algorithm? This was not totally clear from the text.

Zhou et al. (2016) compare results from AIRS (not IASI) and GOSAT. The statement about “A prevalent bias. . .between both satellite retrievals” is confusing. Since the Zhou et al. paper does not appear to include any independent validation measurements and deals only with a comparison between two satellite retrievals, I assume that you are referring purely to the difference between the retrievals, in which case, you should state clearly which one is biased high relative to the other.

As an aside, a point that is not discussed in the Zhou et al. paper, but which has been referred to in AIRS papers and presentations (for example, in Xiong et al. [2008]) is that in those AIRS CH<sub>4</sub> retrievals, absorption coefficients are tuned within the radiative transfer algorithm in order to produce better agreement with validation data (a different form of correction).

Xiong, X., C. Barnet, E. Maddy, C. Sweeney, X. Liu, L. Zhou, and M. Goldberg (2008), Characterization and validation of methane products from the Atmospheric Infrared Sounder (AIRS), *J. Geophys. Res.*, 113, G00A01, doi:10.1029/2007JG000500.

Page 2, lines 34-36: I think it would be good to refer here to the use of a similar correction approach using empirical orthogonal functions within the OCO-2 Level 2 algorithm. To my knowledge, the OCO-2 approach is not discussed in any journal papers to date, but you can find discussion of the use of empirical orthogonal functions in the OCO-2 Algorithm Theoretical Baseline Document (ATBD), available at: [https://docserver.gesdisc.eosdis.nasa.gov/public/project/OCO/OCO2\\_L2\\_ATBD.V6.pdf](https://docserver.gesdisc.eosdis.nasa.gov/public/project/OCO/OCO2_L2_ATBD.V6.pdf)

Page 3, line 27: It is not clear to me what is meant by “an effective H<sub>2</sub>O column to

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calculate the water continuum independently from the water vapor absorption lines.”  
Can you please expand on this point?

Page 6, Fig 1: Please label the altitude axis on the right hand side of the figure.

Page 7, line 1: Suggest removing the word “reduced”.

Page 7, lines 18-19: “the fact that the null space contribution of the integrated methane column is typically in the order of 30 %”. Did you show this somewhere? Please elaborate.

Page 9, line 7: Suggest replacing “cloud clearing” with “cloud screening”, since the term cloud clearing has a particular meaning to some members in the TIR sounding community (Suskind et al., 2003).

Suskind et al., IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING,  
VOL. 41, NO. 2, FEBRUARY 2003

Page 10, line 9: "Indicatory" is not a word that would be commonly used. Suggest saying instead that the difference is representative.

Page 11, Figure 4: Why choose this order for the TCCON stations? Consider arranging them by latitude.

Grammar/typographical errors:

Page 3, line 14: Suggest splitting the points about the 10 km footprint and the sparse spatial sampling into two separate sentences for clarity.

Page 3, line 15: Coarse should be course.

Page 3, line 16: Should this be v160160?

Page 2, line 15: Tropospherical should be tropospheric.

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