Review of “A study of synthetic $^{13}CH_4$ retrievals from TROPOMI and Sentinel 5/UVNS”

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The paper is clearly written and structured, and lays out a straightforward analysis of the feasibility of retrieving $^{13}CH_4$ from two different spectral windows given the instrument characteristics and spectral resolution of TROPOMI and Sentinel 5/UVNS.

Unfortunately I think the study is fundamentally flawed in its assumption that a ∂^{13}C uncertainty of 10‰ is sufficient to differentiate source types. This has already been pointed out in the interactive discussion (Röckmann, 2019), which indicated that such large signals are rarely measured *in situ* in the boundary layer, let alone in the total column. The response from the authors referred to a study by Fisher et al. (2017), using airborne measurements above boreal regions, claiming that they measured an integrated signature of -70‰ over wide tracts of land. This is a clear misinterpretation of the findings of Fisher et al. (2017): If one refers to Figure 6 of this paper, it is clear that ∂^{13}C values varied by less than 1‰, between -47.7‰ and -46.7‰. Only by finding the intercept on a Keeling plot (Keeling, 1958) do they deduce that the source which is adding methane to the background has a signature of -70‰. This is never measured directly, outside of chamber measurements.

The authors further suggest that regional isotopic signatures could be incorporated into global and regional models, and that these models could then be compared against S5 measurements of ∂^{13}C. My colleague Tonatiuh Nuñez Ramirez has done just this in the course of his doctoral studies (in preparation), and has allowed me to use his modelled $\partial^{13}C$ fields for this review. Using the TM3 transport model, he has used regional isotopic signatures for a range of source categories, drawing upon literature values. He has then performed inversions to adjust the methane fluxes based upon the additional constraint of *in situ* $^{13}CH_4$ measurements. Thus these fields should be representative of realistic variability for both CH_4 and $^{13}CH_4$. The resultant ∂^{13}C fields were calculated following Equation 2 of the manuscript being reviewed here.

Figure 1, shows the resultant ∂^{13}C value in the lowest-most model level for a single time step, namely July 1, 2010 at 00 UTC. The model resolution is rather coarse at $\sim$3.8° by 5°, but this is consistent with the spatial averaging that is foreseen by the authors in order to improve the precision of the spaceborne measurement. Note that here the maximum range across the entire globe is less than 5‰, and this is for near-surface values, where the variability can be expected to be the highest. While there is a large range in the isotopic signature of different source processes, the atmosphere is constantly mixing and diluting these signatures with the background values.

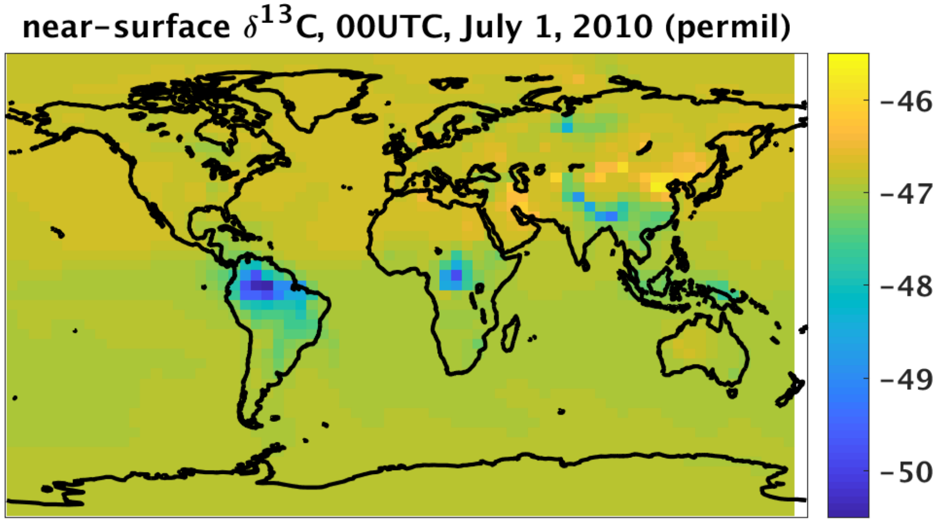

Figure 1. An instantaneous plot of ∂^{13}C in the model level closest to the surface for July 1, 2010 at 00 UTC.

To see the effect of looking at the column-integrated values, refer to Figure 2, in which the range is less than 2‰. Recall that this is for an instantanous value: when averaged over time, such as the monthly or seasonal scales suggested in the manuscript, the gradients are even further reduced. Also, a flat averaging kernel (i.e. pressure-weighted average) was assumed. Given the lower sensitivity in the lower troposphere presented in the paper, the actual gradients would be even smaller.

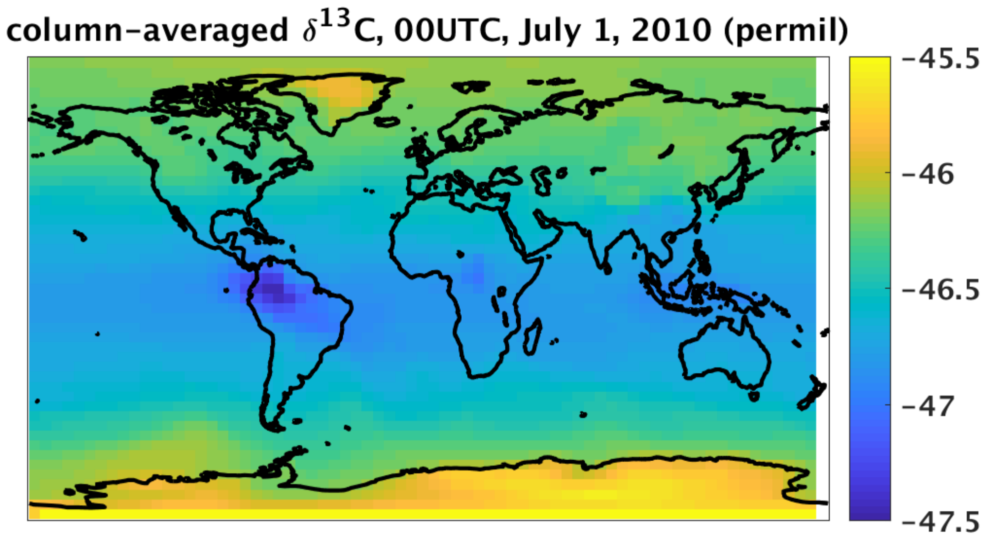

Figure 2. An instantaneous plot of modelled pressure-weighted column-averaged ∂^{13}C for July 1, 2010 at 00 UTC.

Based on this analysis of the signals expected to be seen in the atmosphere, I find that I am forced to agree with the critical comment of (Röckmann, 2019), and conclude that the precision requirement assumed in the paper is not sufficient for scientific interpretation. Indeed, a precision at least a factor of 10 higher would be required. While it is true that the 10‰ requirement has already been published in (Malina et al., 2018), it does not hold up to scrutiny. As such, I cannot recommend this paper for publication.

Should the editor disagree, and choose to publish the paper as a theoretical exercise in retrieving potential signals larger than those found in the Earth's atmosphere, I have a series of minor comments, outlined below.

1 Minor comments

P1, L20: CO_2 is not really the "main GHG", but rather the "main anthropogenically-influenced greenhouse gas".

A recurring comment: I’m not sure if it’s a typesetting issue, but there are several inconsistencies with nested parentheses, including: P1, L22-23; P2, L8-9; P7, L24-25; P8, L30; P25, L2

The wrong citation form (again with the parentheses) is used in P3, L19.

P3, L32-35: the abbreviation "sect" should be "Sect.", I guess.

P4, L13: add a comma after citation.

P4, L18: In English colons are usually used for denoting times.

P5, L4: I’d hyphenate it as: "36-layer plane-parallel"

P5, L28: I feel like a word is missing, perhaps "spectral dependence of surface albedo"?

P6, L14: identified -> described

P6, L21: data "are"; also P9, L22

P6, L25: The are/will be construction to denote present and future is awkward and should be rewritten.

P7, L4: instrumentin -> instrument in

P8, L28: funny (LaTeX?) quotes on ‘truth’; also on P6, L23; P25, L9

P16, L6: should "renders" be "reduces"?

P16, L7: I’d suggest changing "to better knowledge of the ancillary information" to "to improve knowledge of the ancillary information". While "better" can be a verb, here it makes it difficult to parse.

P17, L11: The sentence starting with "While" should be combined with the previous sentence (with a comma).

P21, caption: Should say SWIR3.

P22, L7-8: Reads a bit awkwardly, could be rewritten.

P23, L2: up roughly -> up to roughly

P24, L2: failed convergence -> failed to converge

P24, L10: move comma to after "identify"

P25, L23: comparising -> comparing

P28, L10: makes limited impact -> has a limited impact

P28, L12: remove comma

P30, L4-5: the Hudson bay -> Hudson Bay

References

Fisher, R. E., France, J. L., Lowry, D., Lanoisellé, M., Brownlow, R., Pyle, J. A., Cain, M., Warwick, N., Skiba, U. M., Drewer, J., Dinsmore, K. J., Leeson, S. R., Bauguitte, S. J.-B., Wellpott, A., O'Shea, S. J., Allen, G., Gallagher, M. W., Pitt, J., Percival, C. J., Bower, K., George, C., Hayman, G. D., Aalto, T., Lohila, A., Aurela, M., Laurila, T., Crill, P. M., McCalley, C. K., and Nisbet, E. G.: Measurement of the ^{13}C isotopic signature of methane emissions from northern European wetlands, Global Biogeochemical Cycles, 31, 605–623, https://doi.org/10.1002/2016GB005504, 2017.

Keeling, C. D.: The concentration and isotopic abundances of atmospheric carbon dioxide in rural areas, Geochimica et Cosmochimica Acta, 13, 322 – 334, https://doi.org/https://doi.org/10.1016/0016-7037(58)90033-4, http://www.sciencedirect.com/science/article/pii/0016703758900334, 1958.

Malina, E., Yoshida, Y., Matsunaga, T., and Muller, J.-P.: Information content analysis: the potential for methane isotopologue retrieval from GOSAT-2, Atmospheric Measurement Techniques, 11, 1159–1179, https://doi.org/10.5194/amt-11-1159-2018, https://www.atmos-meas-tech.net/11/1159/2018/, 2018.

Röckmann, T.: Interactive comment on "A study of synthetic $^{13}CH_4$ retrievals from TROPOMI and Sentinel 5/UVNS Part 1: non scattering atmosphere" by Edward Malina et al., Atmospheric Measurement Techniques Discussions, https://doi.org/10.5194/amt-2018-450-SC1, 2019.