

Reply to Anonymous Referee #1 (Received and published: 11 May 2017)

We thank the reviewer for providing us with feedback on the manuscript quickly. We have attempted to revise the manuscript based on the comments. Hope the readability of the manuscript is now improved.

This paper shows that variability in XCH₄ measured by satellite over India cannot be simply attributed to spatial/seasonal variability of local sources but reflects also major influences from the free troposphere. This is a simple argument and is of some interest because there is indeed temptation to make such an attribution, and the paper shows clearly that it is incorrect. The paper also presents a nice analysis of the factors controlling methane in the free troposphere over India. The scope of the paper is limited (hence my rating of "Fair") because it applies only to India, and because a more thorough analysis of XCH₄ data (such as with an inversion) would obviate the need for the incriminated assumption. I was hoping to get a better understanding of methane sources in India but in fact this is not what the paper is about. Still, one could cite the paper as an admonition to pay attention to the free troposphere when making simple interpretation of XCH₄.

Response: The Indian region (South Asia in general) exerts a significant impact on the global CH₄ emissions. About 10% of total CH₄ emissions (550 Tg/yr) is emitted from the South Asian region (Patra et al., 2013). Investigations of sectorial emission of CH₄ over Indian region are thus significantly important, particularly over the Indo-Gangetic Plain (IGP) as the region is well-known hotspot of emissions of anthropogenic greenhouse gases. The transport mechanisms over the IGP and the Himalayan region are of global importance for transport and transformation of methane and other air pollutants; refer for example the aim of the SPARC/IGAC jointly sponsored activity - Atmospheric Composition and the Asian Monsoon (ACAM) project (<https://www2.acom.ucar.edu/acam>). It may also be pointed out here that there are several important projects being planned to achieve the ACAM goals (e.g., Stratospheric and upper tropospheric processes for better climate predictions; <http://www.stratoclim.org/>). Thus, we believe understanding the transport of CH₄ in one of the strongest monsoonal regions of the globe is not likely to be of a limited interest.

The space-based observations are limited to total columnar methane mixing ratios (XCH₄). However, our knowledge of handling total column data in an inverse modelling system is limited and serious systematic biases require attention (e.g., Ostler et al., AMT, 2017). Thus, it is important to understand the source receptor relationships before inverse modeling of regional sources and sinks. Linking the surface emissions to the XCH₄ observations over the Indian region is not very straightforward because of the coexistence of deep convection and large emissions of CH₄ from a variety of both natural and anthropogenic sources. Therefore, recognizing the role of transport is extremely important in order to understand the contributions of emission signals to the XCH₄ variabilities.

We have revised manuscript text to clarify the aims of this manuscript in a significantly revised version. We would like to request the reviewer to take a look in to the revised version now uploaded.

The presentation of the paper could be improved to make it more attractive: the writing is fastidious with too much details, the grammar and style are often poor, the postage stamp figures scare the reader away (could you make do with fewer panels), and the math isn't clean.

Response: We apologize for the sloppiness in writing the submitted version. We have put our best effort in improving the presentation of text. We add or remove some unwanted and confusing text throughout the manuscript. The presentation of results and conclusion become now more clear and straightforward. We present the column calculation equation in Section 2.2 now in a simplistic way. A preliminary version was checked by a language editing service, but some late revisions did not go through the language check. Thank you very much for kindly providing us with quick comments.

However, we have not made any changes to the figures yet, which we plan to do at the formal revision stage, when allowed.

One minor thing: on line 42, delete “increase in”.

Response: The sentence has modified now in the revised manuscript.

References:

Patra, P. K., Canadell, J. G., Houghton, R. A., Piao, S. L., Oh, N.-H., Ciais, P., Manjunath, K. R., Chhabra, A., Wang, T., Bhattacharya, T., Bousquet, P., Hartman, J., Ito, A., Mayorga, E., Niwa, Y., Raymond, P. A., Sarma, V. V. S. S., and Lasco, R.: The carbon budget of South Asia, *Biogeosciences*, 10, 513-527, doi:10.5194/bg-10-513-2013, 2013.

Ostler, A., Sussmann, R., Patra, P. K., Houweling, S., De Bruine, M., Stiller, G. P., Haenel, F. J., Plieninger, J., Bousquet, P., Yin, Y., Saunio, M., Walker, K. A., Deutscher, N. M., Griffith, D. W. T., Blumenstock, T., Hase, F., Warneke, T., Wang, Z., Kivi, R., and Robinson, J.: Evaluation of column-averaged methane in models and TCCON with a focus on the stratosphere, *Atmos. Meas. Tech.*, 9, 4843-4859, doi:10.5194/amt-9-4843-2016, 2016.