

Interactive comment on “A new insight on tropospheric methane in the Tropics – first year from IASI hyperspectral infrared observations” by C. Crevoisier et al.

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First, we d’like to thank the two anonymous reviewers for their positive comments and suggestions. Some changes to the manuscript have resulted from them. Detailed responses to the questions raised by the reviewers may be found below.

General comments

• *Retrieval over land and at higher latitudes*

As explained in the text, retrieval are easier to perform in the tropical region because of the reduced variability of the atmospheric temperature profile, which facilitates the

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decorrelation between temperature and CH₄ signals in the IASI observed brightness temperatures. The extension to higher latitudes is possible, and is presently under study, but some tests need to be carried out to assess the precision that could be obtained, and to adapt the inference scheme (neural architecture, etc) to the processing of temperate situations. Concerning the retrieval over land, AMSU channel 6 is modestly, though significantly, sensitive to surface, and particularly to relief. Hence, performing the retrievals over land requires a more detailed study of the influence of surface elevation: so far, the present application is limited to sea cases. Finally, the extension of the retrieval to daytime is ongoing through the computation of the radiative biases and the design of the cloud mask. These points have been clarified in the conclusion.

● *Line mixing and water continuum*

The spectral range used to perform the retrievals can be affected by two phenomena: line mixing and water continuum. Both have been taken into account in the simulations and thus in Figure 1. The line-mixing parameterisation is taken from Niro et al. (2005). The sensitivity to water continuum may be derived by comparing simulations performed with and without inclusion of the continuum (quite an aggressive change). For the nine selected channels, this has resulted in a signal of 0.01 K on average over the tropical TIGR simulations with an associated standard deviation of 0.05 K. An error in the continuum will thus have a greatly reduced impact on the retrievals (much lower than the actual precision of the retrievals). Moreover, the radiative biases described in Section 3.3 take into account any imprecision in the simulation of the continuum and line-mixing.

● *Vertical sensitivity of the retrieval*

Our retrievals are insensitive to the lower troposphere and the tropopause, as it is well seen on the Jacobians (Fig. 2) and the averaging kernel (Fig. 3). This is a characteristic of emission-based sounding methods as in the thermal infrared and is the case for

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any retrieval of gas concentration (e.g. Crevoisier et al., QJRMS, 2003). This is also in agreement with the paper by Razavi et al. (this issue) which state in their conclusion: “We have firstly derived global distributions of methane total columns using the ν_4 absorption band. (...) We have shown that these distributions (...) are mostly representative of methane concentrations in the middle troposphere, from 4 to 10 km.” As suggested in this paper, the ν_3 absorption band around $3.8 \mu\text{m}$ may bring some information on the lower atmosphere. However, this still remains to be assessed. Moreover, retrievals performed using the ν_3 band would only be possible in very particular conditions (high reflected solar radiation). The use of the ν_4 band only, although yielding retrievals only in the middle troposphere, allows the retrieval of methane in all (clear) conditions, yielding an homogeneous long time record of tropospheric methane.

Response to Anonymous Referee 1

• *The paper "A new insight on tropospheric methane..." by Crevoisier et al shows first upper tropospheric methane retrievals from the IASI instrument. Even though the paper nicely illustrates and characterises the IASI retrievals, I think that the title and abstract actually promise more than the paper delivers. This is not meant in terms of retrieval properties but in terms of insight into atmospheric methane. What do the authors exactly mean by "new insight" in the title? A new retrieval with new data or truly new insights into tropospheric methane sources not yet published from SCIAMACHY or AIRS? I would propose to change the title in order to be less misleading (or to give valid reasons to keep it as is).*

• *Page 6858, line 21 "... our presently quite limited knowledge of its tropospheric distribution". Again, I consider this an exaggeration, given previous results from the ground-based stations as well as SCIAMACHY and AIRS. What did we gain from IASI specifically (as opposed to previous work)?*

Ground-based observations and SCIAMACHY provide information either on methane at the surface or on the full column of CH₄, and do not differentiate the tropospheric

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contribution from the lower atmosphere contribution. Moreover, very few aircraft campaigns measuring methane in the free troposphere exist. Thus our knowledge of TROPOSPHERIC methane distribution is still quite limited. AIRS have provided some information on the tropospheric distribution of methane (Xiong et al., 2008ab). However, IASI has a higher spectral resolution than AIRS in the methane absorption band, yielding nine channels with greatly reduced sensitivity to water vapor, and a reduced radiometric noise, and hence improved retrieval characteristics. In the title, we were thus referring to the development of new retrieval with new data (both in terms of instrument and spectral characteristic). To avoid any confusion, the title has been changed to “Tropospheric methane in the tropics: first year from IASI hyperspectral infrared observations”.

• *Introduction, line 15 "... sources and sinks are not as well understood as those for CO₂" This is a rather vague statement. ...*

The reference to CO₂ has been removed.

• *Introduction, line 18 Please add Bergamaschi et al (JGR, 2007) at this point*

The reference has been added.

• *Page 6857, line 27 "... would in principle fill this gap" They do already as shown by inversions presented in Bergamaschi et al 2007, Meirink et al 2008 and Frankenberg et al 2008. If only ocean pixels are provided in this study, many important gaps still remain.*

The sentence has been modified. However, it must be said that despite several studies using CH₄ atmospheric distribution derived from space observation (mostly from SCIAMACHY) to infer surface fluxes, results are still in debate and the characteristics of methane sources are not fully elucidated. So, in our opinion, the gap has not been filled yet, and more than one instrument will be needed to fully grasp the methane budget.

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- *Page 6866, line 24 What is a "systematic" aircraft measurement?*

"Systematic" has been replaced by "regular".

- *Page 6869, line 23 "bias" sounds judging (ie either model or IASI is supposed to be wrong, not clearly stated here). Better talk of differences.*

No negative judgement was intended there! "Bias" has been replaced by "difference".

- *Page 6870, line 4 "too weak convection in the model" Very vague and unsubstantiated. To support this statement, MOZART should be confirmed to agree at the surface with eg GMD-stations. As I understood, the MOZART fields are based on a pure forward model run and are not optimised wrt ground based measurements. Hence, no conclusion can be drawn whether there are biases in a priori emission inventories or model convection parameterisation.*

Biases in the simulation could indeed be caused by 1) biases in the a priori inventories, which have not been constrained by any observations or/and 2) by model convection parameterization. The sentence has been modified accordingly.

- *Page 6870, line 12 "much lower than observed by Frankenberg" How do you derive this conclusion if there is no quantitative comparison (and no land pixels)? SCIAMACHY and IASI are hard to compare owing to different sensitivities. A statement like this, however, is not possible/valid.*

The methane values observed around Central and Northern South America are much less than what would be required to match the very high methane emissions found by Frankenberg et al. (2005), whereas they are consistent with the values retrieved by Frankenberg et al. (2008).

- *Page 6872, line 22+ Accuracy: As said before, I would consider this a precision estimate as it describes random errors within a grid cells.*

"Accuracy" has been replaced by "precision".

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