

***Interactive comment on* “Characterization of methane retrievals from the IASI space-borne sounder” by A. Razavi et al.**

Anonymous Referee #1

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General remarks

The paper "Characterization of methane retrievals from the IASI space-borne sounder" by Razavi et al presents first global total column retrievals using the methane ν_4 absorption band. The authors also discuss the opportunity to retrieve methane in the 2760cm⁻¹ region where solar light substantially contributes to the total signal and hence enhances the sensitivity towards lower atmospheric layers. In general, the paper is well written and concise. Further, it is the first to attempt total column retrievals from IASI which is a challenging task with large scientific potential. In some aspects, however, the authors seem to be overly optimistic and their very low error estimates cannot explain the observed features which are, when compared with ground-based concentrations or SCIAMACHY retrievals, partially unrealistic. This concerns some major comments which definitely need to be addressed before being suitable for

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publication. Given error estimates should be definitely revised as they are misleading and promise a kind of data quality that I really don't see in the global maps.

Major comments

- **all related to the choice of S_a**

In figure 4, the a priori covariance (diagonal elements) is depicted. I guess the 1-sigma levels are indicated but this is not clear to me (please clarify). The stratospheric variability in S_a seems to me far too low especially as a global climatology is applied while concentrations at the 15-20km levels at higher latitudes can even be below 1ppm. As the North-South gradient is largely determined by stratospheric variations, the strict choice of S_a will largely dampen the retrievals (or put changes in other height layers).

It would also be better to provide S_a in its matrix form (eg surface plot) in order to judge the off-diagonal elements. My main concern is the following: I am surprised by the high sensitivity towards surface layers and wonder whether this might be influenced by strong correlations with higher layers introduced by S_a . How do the averaging kernels change if the lowest 1-2km are decoupled (in S_a) from other layers (which is not an unreasonable assumption as methane can accumulate in the boundary layer)? Similar to this remark, it would be useful to add total column kernels in figure 5 and to extend the y-axis to 0 (why does it stop at 2km, this is not clear to me).

Figures 7 and 10 show actual retrievals, with values up to 2.1ppm. If I read the S_a values correctly, this would be up to 3-5 σ higher than the prior. Hence, the retrieved state is far away from the prior and the retrieval tries to just shift the profile as this minimises the penalty introduced by S_a . This can be seen in Fig. 10 where the retrieved profile seems uniformly shifted by about 200ppb (ie more than 2 σ). Either, the retrievals are strongly biased (which seems more realistic) or the prior is chosen too low and too conservative in terms of variations.

Ground-based retrievals in Alert, for instance, are on average about 1850ppb and seldom exceed 1900ppb. Retrieved values of up to 2ppm in the total column at high latitudes therefore seem unrealistic and cannot be reconciled with the 1-1.5% error estimate for the total column.

Considering the strict S_a and deviations from the prior: It would be worthwhile to investigate how a relaxation of S_a (or shift in x_a) change the fit residuals. Given the large deviations from the prior, the penalty induced by this deviation might influence the fit residuals as the retrieval becomes too constrained. Furthermore, the posteriori error estimate is (in case the retrieved state is far away from the prior) largely constrained by S_a .

sensitivity to the total column

There is another IASI paper on ACPD by Crevoisier et al. One sentence reads: "Hence, IASI only allows the retrieval of a mid-to-upper tropospheric integrated content of methane". Please discuss why your retrievals are sensitive to the lowest layers (ie what is conceptually different in the approach) and how you manage to obtain an error as low as 1% for the total column. In particular, I would like to see evidence that boundary layer enhancements can be detected by IASI. For this purpose, you could even perform a synthetic retrieval with enhanced methane only in the 0-2km layer (say 200ppb higher than the prior). Would IASI really detect this signal or is the high sensitivity to this layer artificially introduced by S_a ?

The potential of IASI is promising but is is rather bold to claim 1% error in the total column while there are unrealistic values as high as 2.1ppm. Results should be compared with optimised model fields (eg optimised to ground-based stations) in order to draw any preliminary conclusion on errors. As far as I can judge, the choice of S_a and some unaccounted systematic errors lead to an unrealistically low a posteriori error estimate.

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Figure 7 Please change to another projection that allows to see the entire earth. Why are the tropics so low even though SCIAMACHY, IASI (in Crevoisier et al) and atmospheric models (mainly because the tropics are well mixed with high values throughout the column up to the high tropopause)? Is there a problem with water vapor interferences (as discussed and eliminated in Crevoisier et al)? Surprisingly, the colorscale ranges from 1840-2000ppb which is inconsistent with Crevoisier et al results, SCIAMACHY retrievals, ground-based measurements and TM5 model fields (eg Schneising et al, ACP, 2009). Basically, your lowest values are even higher than the highest values in other retrievals. How can this be explained?

Page 7626, lines 10+ Again, I consider it rather bold that the features with high values correlate with regions of typical methane emissions. I don't think this statement is justified (what happens over the oceans, why are the values way too high, why don't you see stratospheric depletions in polar air??)

Specific comments

- **Page 7616, line 24** *1774.62+-1.22: I would skip the last two digits.*
- **Page 7616, line 17** *large uncertainties still exist*
- **Page 7628, lines 8+** *is an increase of 0.06 DOF really significant? The potential of adding this spectral region is enticing but from Fig 10 it looks as if both retrieval windos are not yet consistent.*
- **Figure 10** *From which location is this retrieval? You could compare surface values with NOAA GMD measurements (via the interactive data viewer). I am pretty sure you will not find 2.0ppm.*

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