Referee comments in bold.
Responses in normal type.

The abstract states that the scheme is novel in the use of "precisely fitting measured spectra in the 7.9 micron region to allow information to be retrieved on two independent layers centred in the upper and lower troposphere" and "making specific use of nitrous oxide (N2O) spectral features in the same spectral interval to directly retrieve effective cloud parameters to mitigate errors in retrieved methane due to residual cloud and other geophysical variables" were both previously done by Worden et al. (2012). The statement that this is novel should be removed. The authors could state that they have developed a novel variant of N2O correction.

The abstract has been re-phrased accordingly.

The abstract and conclusion gives only errors for the column. The abstract and conclusions should give the errors for the new vertically resolved quantities. In the conclusions, if errors are also given for column CH4, these should be compared to current IASI CH4 products.

Errors for vertically resolved quantities are now added to abstract and conclusions.

Crevoisier et al. (2009) estimated precision on methane retrieved by their neural net scheme in the mid/upper tropospheric layer to be 16 ppbv for a 5 × 5 deg spatial resolution on a monthly time scale. Comparison with individual soundings with our scheme on a like-for-like basis could be informative, however, this was beyond the scope of our paper.

P8 L20. The article states that the averaging kernel and predicted errors are more accurate in the new scheme versus previous methods where N2O is retrieved and then used to correct CH4. To make this claim, comparisons of results, averaging kernels, and predicted errors need to be shown between the method where N2O is fixed versus retrieved, at least for a few cases. The results where N2O is retrieved must include the retrieval of cloud parameters to make it a fair comparison, as the previous scheme this tries to improve on, e.g. Worden et al. (2012), retrieves cloud parameters jointly with N2O and CH4.

Since we have not quantitatively tested the benefit of the improvement in AKs from our cloud-modelling approach, the text in the introduction (2^{nd} bullet) has been modified.

The title of the article is "Global height-resolved methane retrievals..." and yet most of the results shown are column results. Comparisons to TCCON and GOSAT are of limited interest to this paper because they are not vertically resolved. The only reason to compare the total column is if the new retrieval improves over the current IASI column.

The emphasis on column average comparisons is driven by the fact that almost all available independent observational data is of that type. In particular, TCCON provides the most extensive and well-established correlative data set with which to assess the IASI retrievals. We therefore consider it important to compare with TCCON and column average data from GOSAT. Nevertheless, we do take the point, and now include additional results (new figures 7 and 11) comparing the IASI 0-6km layer average with MACC (the only data-set other than HIPPO which allows height-resolved comparisons).

In addition, ESDs and averaging kernels are now presented for the two layers in figures 3 and 4.

If this is the case, both new and current IASI CH4 results should be shown.

As stated above, comparison with other IASI methane datasets was not feasible and so beyond the scope of this paper.

HIPPO is primarily over ocean. The authors need to validate the height-resolved CH4 over land.

The theoretical performance of our scheme is characterised in the paper over land and sea. We have used the height-resolved observational data from HIPPO which is available. The MACC comparisons have performed over both land and sea, and the TCCON comparisons are predominantly over land. We are not aware of another observational data set against which height-resolved IASI data over land could have been extensively compared.

Specific comments:

P.2 Line 18. The word "also" is confusing and should be taken out.

Done.

P2 L32 "Sophisticated use" is not a useful description of what the authors are doing. I would reword this to something like, "Use of an fixed N2O volume mixing ratio values, based on ACE climatology described in Section XX, to retrieve cloud parameters in the CH4 spectral region."

We believe the wording of Section 2.4 to now be quite clear.

P5 L16. The description of the N2O a priori definition is sufficiently important to the paper that it should be in its own sub-section so that readers can easily find it. It should not be under the heading "forward model".

This has been moved to a separate section.

P3 L13 "coupled to sophisticated modelling...". The use of the word "sophisticated" is not useful. Something like, "coupled to modeling of N2O based on the ACE climatology, parameterized by latitude, pressure, and date, as described in Section ##." Please remove all other instances of the word "sophisticated".

The sentence has been re-phrased and the word "sophisticated" is also removed elsewhere.

P3 L12 "described by Kulawik 2006 and Eldering 2008, however this uses a much wider spectral range (8-15 microns)" It's not obvious from the above cited papers, but although the cloud parameters are initially estimated using 8-15 microns, cloud parameters are then retrieved in the windows used for each retrieved species. For methane, the windows are 7.5-8.4 microns.

This statement in our paper has now been modified to specify that Worden 2012 includes cloud parameters but jointly fits N2O. It is difficult to see where the information on cloud comes from in their approach. We assume it to be well constrained by their broad-band retrieval, however this is not clear from their papers.

P3 L6-15. It appears N2O is set and then not retrieved. Could you state this explicitly? It's currently confusing to the reader what you are doing.

This is now stated explicitly.

P5 L29. "Column average mixing ratios from retrieved methane profiles are positively biased compared to independent measurements by approximately 4%, with a systematic height-dependent structure in the profile." It needs to be clarified what is being compared to and a citation or reference to a later section needs to be given.

Clarification has now been provided in a footnote.

P5 L31. I'd cite the Alvarado, 2015 paper for TES biases.

Citation now added.

P5 L31. The TES bias in Alvarado, 2015 is twice as much in the upper troposphere as lower. MIPAS does not see into the lower Troposphere. If IASI sees a 4% bias in the lower Troposphere and no bias in the upper Troposphere, this result is somewhat different from previous results.

We do not wish to contend that the biases are identical, but only to point out that other schemes have been found to exhibit comparable biases, which might point towards spectroscopic issues and possibly thereby motivate future work in that area. The statement has been modified to avoid an impression that the biases are entirely consistent.

P9 L30. Since IASI columns are being compared to GOSAT and TCCON, it is important to show the column averaging kernel and compare to that of GOSAT and TCCON (e.g.see Boesch et al. (2011), figure 13). The values in Fig 1 of 0.15 or 0.2 impossible to compare the sensitivity of the column averaging kernel.
P10 L 22 and Figure 4.

The averaging kernel for IASI column average methane is now shown in figures 1 and 3. In figure 1 the values of the kernel are divided by 10 (so as to fit on the same range) – this was not sufficiently clear before so we have now added this to the figure caption. Apart from this scaling, the kernel should be directly comparable to that of Boesch et al. 2011. We do not consider it necessary to present their kernels here, however, since whether or not they are used (via eqn 13) makes very little difference to our IASI comparisons to GOSAT or TCCON, so the detailed GOSAT/TCCON kernel shapes are of secondary interest, and they can be seen in the cited reference.

Please define the DOF's for the column averaging kernel.

We have presented DOFS for the retrieval state vector. If reformulated to retrieve a methane column average mixing ratio instead of a height-resolved profile, the corresponding DOFS would be unity, so we are not clear what the Referee intends by this request.

I don't think a single parameter quantity, e.g column amount, can have degrees of freedom above 1, by definition. Can you show the sum of the trace of the averaging kernel for the CH4 profile, and/or the DOF for the lower and upper partial columns for CH4.

DOFS for the profile are given in figure 1, these are determined from the trace of the averaging kernel. The caption has been extended to clarify this. Layer average mixing ratios are computed from the retrieved profile, as described in Section 3. Please see response to previous point.

P10 L18 As discussed in general comments, to support the assertion that you have height resolved methane retrievals, in addition to the 6-12 km results, 0-6 km or 3-6 km comparisons to MACC need to be shown.

These are now included.

P18 L16. The HIPPO comparisons in Figs 14-15 of 0-6, 6-12 and total column are good. The biases are summarized in the text. Please also mention the standard deviation in the text, abstract, and conclusions.

Standard deviations and their relation to ESD were already discussed in relation to figure 15 (now figure 17); to which we have added some more quantitative values. The extent to which these results support the estimated random errors on the layer averages is now mentioned in the conclusions. We do not consider that a specific point in the abstract is necessary.

Conclusions. The conclusions only discuss results for column CH4. As the paper is on height-resolved methane retrievals, the discussion needs to emphasize results for height-resolved quantities of 0-6 km and 6-12 km.

Text has been added accordingly.

Figure 6. Show MACC with the IASI averaging kernel (Eq. 12) for day and night. In particular, I'd want to see that the day/night differences seen in IASI are due to sensitivity not variations in CH4.

Day – night variations in retrieved CH4 cannot be tested in this way because the MACC data are daily average methane values (as mentioned in the paper), so the differences shown specifically relate to IASI day-night differences in sampling/sensitivity; to assess diurnal variation in methane, a different model would need to be introduced.

Figure 9-10. Show comparisons for 0-6 km also.

This has been done (new figure 11).

Figures 11-14. These figures are column-based and do not support the validation of height-resolved methane retrievals. If the assertion is that the full-column retrievals are also improved, results should be compared to current IASI CH4 retrievals. Otherwise results should focus on height-resolved validation.

As pointed out above, we consider comparison to TCCON to be important and this can only be done via column average comparisons. Our response to the Referee's earlier comment applies here:

The emphasis on column average comparisons is driven by the fact that almost all available independent observational data is of that type. In particular, TCCON provides the most extensive and well-established correlative data set which to assess the IASI retrievals. We therefore consider it important to compare with TCCON and column average data from GOSAT. Nevertheless, we do take the point, and now include additional results (new figures 7 and 11) comparing the IASI 0-6km layer with MACC (the only data-set other than HIPPO which allows height-resolved comparisons). In addition, ESDs and averaging kernels are now presented for the two layers in figures 3 and 4.