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Atmospheric Chemistry and Physics Discussions

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

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 radiatiave 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

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 ν4 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 ν3 absorption band around 3.8 μm may bring some information on the lower atmosphere. However, this still remains to be assessed. Moreover, retrievals performed using the ν3 band would only be possible in very particular conditions (high reflected solar radiation). The use of the ν4 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.

Specific response to Anonymous Referee 2

•*Abstract, page 6856, line 7: IASI spectral resolution is high for a meteorological sounder but rather medium for an instrument dedicated to chemistry. "very" could be avoided here and similarly on Page 6858, line 18.*

Text has been changed.

•*Page 6858, line10: IMG operated for several months but only intermittently. "few operation periods of successive days" may be more suitable than "a few months of observation"*

Done.

•*Page 6859, line 20: There are 30 scan positions making up a total of 120 measurements. This should be added and also it should be specified if all these individual measurements were analyzed or if only a 4-pixel average was considered. The coincidence between IASI and AMSU could also be specified.*

To increase the signal to noise ratio, and speed the learning phase, we have chosen to divide the infrared noise by 2. This requires using the average of the 4 IASI BT con-

tained in each single AMSU field-of-view as inputs to the networks. Hence, retrievals are performed at the AMSU spatial resolution. This has been specified in the text.

•*Page 6860, line 4: The "estimated" accuracies referred here are more the "targeted "accuracies. This should be changed. Alternatively the authors could provide an estimate of the current performances for temperature and humidity retrievals if these are available.*

According to Pougatchev et al. (2009, this Special Issue), the std error of Level2 temperature for a single FOV retrieval is 0.6 K between 800–300mb with an increase to 1.5 K in the tropopause, with biases against radiosondes within $\pm$0.5 K between 950–100mb. For water vapor, the std error std for a single FOV relative humidity retrieval is below 10

•*Page 6863, lines 9 through 11: Although it can be understood, this sentence is not well formulated. What does a "decrease in the emission by the surface" really mean?*

The sentence has been changed to: "this low sensitivity is characteristic for emission-based sounding methods and occurs because of the lack of temperature contrast between the surface and the boundary layer".

•*Page 6867, lines 11 through 14: On the seasonal cycles. Low values seem to be observed by IASI in the Northern tropics from mid-March to August without much variations, which is somewhat different than what is mentioned in the text (decrease in March with minimum in July –August)*

The text has been modified accordingly.

•*Page 6867, line 25: "A peak of 10 ppbv is observed. . .". It is unclear what this peak refers to. One would assume this is with respect to the average values but these are nowhere mentioned in the text (and by the way these average values would be very welcome to help quantifying the North-South gradient mentioned page 6868 lines 8-9). In my opinion what is striking in Figure 4 is not only the 10 ppbv peak in January but also*

the low values on both sides (October and April), which seem to be fully consistent at Southern latitudes. With respect to those the increase in January is closer to 40 ppbv, which is similar to the Northern hemisphere amplitude values. Is there a reason for the low October and April values?

Methane retrieved by IASI in January-February between 20S:10S is higher by about 20 pbbv as compared to previous and following months. As seen on Fig. 5, this 'peak' of 20 ppbv has been observed at the surface (as in 2006), but not every year (as in 2007, for which the methane seasonal cycle in the southern hemisphere is more sinusoidal). North to that band, there is a mix between the northern and southern cycle.

•*Page 6868, lines 15-16: The 30 ppbv difference is here for the April-September period, which corresponds to the lowest values at northern tropical latitudes. Does that point to a lower bound for the North-South gradient?*

Yes, the latitudinal gradient will be the lowest during this time period. More observations in the free troposphere would be needed to extend this comparison to the other months.

•*Page 6868, lines 17-19: Are the different amplitude between the middle tropospheric and surface gradients explainable by the proximity of sources and the vertical mixing?*

Yes indeed. This comment has been added.

•*Page 6869 lines 24 through page 6870 line 5: The positive bias between the IASI observations and the models is explained by two possible causes: larger tropical emissions than assumed in the models or too weak convection in the latter. Is one more likely than the other? This may be an important result for future analyzes.*

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. However, no one is more likely than the other here. As suggested by Referee 1, a comparison with simulations using surface emissions already constrained by surface observations (and thus comparing well with these observations) could give

some indication.

•*Page 6870, line 10 through 15: I find it hard to distinguish the plume of CH4 from central-Northern South America (August to September) from other large values at similar latitudes (being even larger for other months). Is this sufficient evidence to make the link with the tropical emission patterns suggested from SCIAMACHY measurements?*

This comment was intended to highlight that the values of methane retrieved by IASI at the proximity of Central and northern South America are more in agreement with the SCIAMACHY results of Frankenberg et al. (2009) than Frankenberg et al. (2003).

•*Page 6871, lines 20-21: I could not find how the values of sigma-M and sigma-V were derived.*

The values of sigma-V were incorrect. They are computed as sum of squared errors.

The technical corrections have been made. The notation 'TB' has been kept for equations and 'BT' for text.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 6855, 2009.