Reply to the interactive comments on "Assimilation of atmospheric methane products in the MACC-II system: from SCIAMACHY to TANSO and IASI" by Massart et al.

1 General reply

We would like to thank the reviewers for their comments and remarks. They helped us to discover an issue concerning our usage of the data from the TCCON network looking closer at the experiment behaviour at the Darwin site. We assumed the modelled CH_4 molar fraction to be wet when it was dry. Therefore Fig. 10 and Table 3 of the paper were updated and the discussion Sec. 3.5.2 has been changed (see Table 1 and Fig. 6 of this reply).

The merits of assimilating the CH_4 dry mole fraction products was not clear when compared to the FREE experiment. To have a better overview of the differences between the experiments and the TCCON data, we computed the optimal quadratic function of latitude for each month that fits the monthly mean difference between the experiments and the TCCON data at each available TCCON site, following Bergamaschi et al. (2009). We then plotted the time series of these quadratic functions (Fig. 11 of the revised version). This figure allows to have a better idea of the time and latitudinal variation of the bias of each experiment (see reply to comments below).

We chose to add more information on the standard deviation of the difference between the experiments and validation data (TCCON and HIPPO) in the revised version of the paper. The standard deviation is indeed an indicator of the error we try to reduce with the assimilation while the average difference is the systematic error (or bias).

The biases should be removed but this is unfortunately not possible in our NRT framework (see reply to the major comments of referee #1 below). Nevertheless, as soon as validation data are available, one can compare our analysis with this data to have a first guess of the bias that the assimilated product may have.

2 Anonymous Referee #1

2.1 Main comments

• *But the study as is focuses on technical aspects and includes little scientific value. As such I do not see it suited for a journal like ACP, but suggest it would be better suited for GMD. There are also a number of issues I think shoud be addressed before publication.*

We prefer to let the decision where to better publish this paper to the editor.

2.2 Major Comments

• *The results demonstrate no clear improvement with the assimilation compared to the free run. Overall the free run actually seems to show the best performance. There are also large differences when assimilating the different products or different retrieval versions of the same product in case of TANSO. Yet the authors do not provide an analysis on the cause of these differences except for a general statement on possible biases in the different satellite products. Such a bias should anyways be addressed in advance of assimilating the products, specifically when jointly assimilating two products (TANSO+IASI). The results as shown give very little confidence in using any of the products for methane assimilation.*

Our paper describes the first results of the assimilation of xCH_4 satellite products to constrain the atmospheric methane. It aims to serve as a starting point from where we have to improve the system. The improvements will come from the assimilated observations as well as from the assimilation system. Even if these improvements will be necessary in the near future, we do think the whole system is now good enough to provide satisfactory results and we do not think that the FREE run seems to show the best performance.

Our experiments suffer from global biases that cannot be removed in near real time (see the answer below about this subject). The assimilation is nevertheless doing a good job reducing the CH_4 concentration in the Northern Hemisphere during the summer (Fig. 5 of the paper). And when the bias is removed, the distribution (both vertical and horizontal) of CH_4 is much better after assimilation as proved by the comparison with the data from the HIPPO campaigns (Fig. 9 of the ACPD paper). For the second period (after October 2011), the new version of Tab. 3 (see above) proves for example that the TANSO+IASI experiment has a better agreement with the TCCON data (global bias of about -0.8 ppb) than the FREE run (global bias of about 4.6 ppb). In order to have an overview of the differences between the experiments and the TCCON data, we computed the optimal quadratic function of latitude for each month that fits the monthly mean difference between the experiment and the TCCON data at each available TCCON site, following [Ber2009]. We then plotted the time series of these quadratic functions (Fig. 6). We would like to include this figure in the new version of the article as it allows to have a better idea of the time and latitudinal variation of the bias of each experiment. The new Figure 11 of the revised version shows that for the second period (after October 2011) the bias of the TANSO+IASI experiment is lower than for the TANSO experiment and they are both low compared to the bias of the FREE experiment.

Concerning the differences between the two versions of the TANSO product, please see appendix A. In summary, the difference comes much more from the prior profiles and the averaging kernels provided with the data than from a bias between the data themselves. We added the information in Sec. 3.5.2 where this becomes obvious and we added the following sentences: "Figure 11c shows a very different behaviour between the two periods of the TANSO experiment (version v.1 of the data before October 2011 and version v.2.0 after) in terms of bias when compared the the TCCON data. This comes from the change in the a priori information (a priori profile and averaging kernel) between the two versions of the product, xCH_4 being similar in the two versions."

The bias of the assimilated data is indeed an issue. We are running the system about 6 months behind real time as soon as the satellite products are ready to be assimilated. These products are already biased-corrected by the data providers but it is a difficult task as unfortunately they do not have independent data in near real-time to properly bias-correct the products. As we want to run the system as close as possible to the real time, we cannot wait for these independent data. If such independent data were available in near real time, another solution would have been to bias correct the assimilated data directly in the assimilation process following Dee and Uppala (2009).

Moreover, before assimilating together IASI and TANSO data, we verified the consistency between them. It's a difficult thing to do as they are sensitive to different regions of the atmosphere (lower troposphere for TANSO, middle troposphere for IASI). Therefore they should not be directly compared. We did compare the IASI data with the columns from the TANSO experiment (using the IASI weighting functions) before assimilating the IASI data. It was not a completely fair comparison but this comparison did not show inconsistencies between the IASI product and the experiment. We also tried to use the TANSO data to anchor the variational bias correction for IASI. This experiment was not successful as the bias correction system was producing an increasing bias with time for the IASI data. We thus simply added IASI without any specific treatment. Assessing its impact in the analysis as we did in the paper can be viewed as a way to identify biases in the product.

• *The observation error is taken from those reported in the data products, but for most satellite products these have been shown to not well represent the actual error established from product evaluations. Can the authors comment on this and have they tested the sensitivity of the results to these assumptions?*

Before running the full experiments, we ran several tests to be sure that the setting of the assimilation system was appropriate. Concerning the observation errors, we did look at some a posteriori diagnostics as described in Desroziers et al. (2005). These diagnostics showed that we should inflate the given TANSO observation errors by a factor of 1.3 for the version v.1 of the data (Fig. 1 of this reply) and by a factor of 1.2 for the version v.2.0 (Fig. 2). For SCIAMACHY, the factor was found to be about 1 (Fig. 3). For IASI, the factor was found to be 0.3 (Fig. 4). We choose nevertheless not to inflate the TANSO observation errors as we were not able to see much difference in the analysis between a factor 1 and 1.3. For IASI, we found the diagnostic not appropriate because of correlations in the observation errors. We thus decided not to apply a correction. Work is in progress to account for the correlations of the observation errors.

• *Can they authors provide estimates for biases and errors associated with the different satellite product from the evaluation with independent data? How do these depend on assumptions taken in the assimilation system (observation error, correlation length, background error covariance, etc.)? How do they compared to reported errors?*

To have broad estimates of the biases and errors of the satellite products, we can first compare one experiment with the satellite products that were not assimilated. For example we can compare the TANSO experiment with the SCIAMACHY product. In June 2011, the difference between the analysis from the TANSO experiment and the TANSO (version v.1) data is 0.5 ± 8.3 ppb for the Northern Hemisphere. The comparison between the same analysis and the SCIMAMACHY data give a difference of 11.8 ± 37.6 ppb. One can therefore assume that the bias between TANSO and SCIAMACHY is 11.3 ppb.

If we perform the opposite computation, the SCIAMACHY experiment compared to the SCIAMACHY data gives an difference of 0.3 ± 33.5 ppb. And compared to the TANSO data the difference is -9.7 ± 14.6 ppb. One can therefore now assume that the bias between TANSO and SCIAMACHY is 10 ppb.

Let's use another data set as a reference. If we choose the data from the HIPPO campaigns, Tab. 1 of the paper would suggest that the bias between the TANSO and SCIAMACHY data for the Northern Hemisphere is 8.83 ppm (-36.38 ppb - (-27.55 ppb)) on average between June and November 2011. In conclusion, the bias between the TANSO and SCIAMACHY data for the Northern Hemisphere in summer could be between 8.8 and 11.3 ppm. The uncertainty in the value comes in particular from the fact that the assimilated data are not exactly at the same place as the validation data, their coverage differ, their vertical sensitivity to the atmosphere is not the same. For example it does not make sense to compare the TANSO+IASI experiment with the SCIAMACHY data in the Northern Hemisphere above 30°N as the constraint in the analysis from the IASI data is low.

For estimating the errors, it is even more tricky. One can make the assumption that the analysis error is low compared to the observation error. Therefore, if we refer to the numbers given previously, the error of the TANSO data should be between 8.3 and 14.6 ppb while the error of the SCIAMACHY data should be between 33.5 and 37.6 ppb. There is again some uncertainty in the values of the estimated errors.

Figure 11 in the revised version can nevertheless be seen as a first guess of the bias of the assimilated data. One should nevertheless be cautious using this information given the limitations.

• *Does the evaluation with HIPPO and TTCON give consistent results? The information is hidden in the results, but should be brought out more clearly.*

Looking at the Tabs. 1 and 3 (middle) we can see consistent results between the evaluation with HIPPO and TCCON data. For example the north-south gradient in the FREE experiment. The bias is positive in the Northern Hemisphere and negative in the Southern Hemisphere for both comparisons with a north-south offset of about 15 ppb for the comparison with HIPPO and of about 9 ppb for the comparison with TCCON.

We can also see inconsistent results. For instance, the value of the bias with respect to the HIPPO data of the TANSO and TANSO+IASI experiments in the tropics is between the values of the bias in the Northern Hemisphere and the Southern Hemisphere. When compared to the TCCON data, the value is always larger than the values of the bias in the two hemispheres. These differences could be the result of the significance of the value of the bias when compared to the TCCON data as we do not have a lot of stations in the tropics. This could also be due to the sensitivity of the TCCON measurements that are columns with averaging kernel while the comparison with the HIPPO data gives the same weight to the whole troposphere.

2.3 Other Comments

• *More information on the details of the assimilation technique, error assumptions etc. are needed*

We already introduced the assimilation technique page 2559 line 25 of the discussion paper (12 h 4-D-Var window). Next page, page 2560, from line 19 to 26 we detailed the assumption on the background and observation errors. And when each satellite product was introduced, we provided information on its error.

• *Line 20, page 2560: what is the background error estimate based on?*

The background error covariances were estimated using the NMC method (Parrish and Derber, 1992). The sentence was modified to add this information: "The background error is derived from the NMC method (Parrish and Derber, 1992) and is set to be constant in time.

• *Line 25, page 2574: shouldn't the assimilation diagnostics be checked to see if the data assimilation system makes proper use of the IASI data?*

As described below, the CH_4 background error covariances were estimated using the NMC method based on an experiment assimilating the SCIAMACHY data. The assimilated data have an impact on the estimation resulting from the NMC method. As the TANSO data have similar characteristics as the SCIAMACHY ones, using the estimated background error for the assimilation of the TANSO products is pertinent. But one can argue that this background error is not pertinent for the assimilation of IASI products. Work is in progress to assess the impact of the IASI data on the estimation of the background error.

• *Line 19, page 2580: more discussion should be given on why IASI assimilation deteriorates the results.*

This is not the case anymore with the comparison with the data from the TCCON network. The conclusion was reshaped.

• *Figure 9: The figure caption is not in line with the text in the manuscript and the figure itself.*

We changed the caption with:" Time series of the HIPPO CH_4 data (latitude vs. pressure) for the four flights (top panel and from left to right) and difference between the experiments and the HIPPO data (last four panels, from top to bottom: SCIA analysis minus observations, TANSO (v.1) analysis minus observations and TANSO+IASI analysis minus observations. A global bias has been removed from the FRRE run and from each analysis (see Table **??**)."

3 Anonymous Referee #2

3.1 General comments

• *There is some information missing about how the satellite data products, SCIAMACHY, TANSO, and IASI were assimilated, i.e. what were the resolutions of the products and how were they used in the data assimilation system. For example, the data assimilation system has a resolution of circa 80 km (T255), while SCIAMACHY has a pixel size of 30 x 60 km, TANSO has a field of view of 10.5 km diameter, and IASI 12 km. The only information, I could find was in the caption of Fig. 2, where it states that the observations are at a resolution of 0.7 x 0.7 degrees, but further information should be given in the text in section 2.2. Furthermore, it is not mentioned whether or not data errors were correlated in time and/or space. Even if the data were assimilated assuming no error correlations, this should be stated.*

We are using all the available pixels of the instrument that are quality flagged. Because the pixel size of the instrument is smaller than the size of the model grid cell, as commented by the reviewer, we could have several observations per model grid cell. To avoid this, we chose to thin the observations on a $1^\circ \times 1^\circ$ grid. We added this information at the end of the first paragraph of Sec. 2.2 with the following sentences: "For each CH_4 products, we used the data at all the quality flagged pixels of the instrument. Because the pixel size of the instruments is lower compared to the size of the model grid cells, we could have the situation of several observations per model grid cell during an assimilation window. The correlation between the observation errors should then be taken into account. To avoid this situation, we thinned the observations on a $1^\circ \times 1^\circ$ grid."

Concerning the observation error covariances, the information could be find in Sec. 2.1, page 2560, lines 24 to 26 of the discussion paper.

• *I think the authors should include (even if only briefly) a discussion of previous studies on the comparison of satellite data products of CH_4 with ground-based observations (especially TCCON) in section 3.5.2. For example, for SCIAMACHY, the work of Houweling et al. and Bergamaschi et al., which also include a discussion of the latitudinal and seasonal dependence of errors.*

We tried to link our study with previous ones on similar topics, as suggested. To start with, we decided to fit the monthly difference between the experiment and the TCCON data with a quadratic function following Bergamaschi et al. (2009) as presented in the general reply. We added the time series of the quadratic functions for each experiment (Fig. 11 of the revised version). For the SCIA experiment our mean difference with the TCCON data is -27 ppb which is between the values found by Bergamaschi et al. (2009) for the SCIAMACHY bias (between -10 and -20 ppb for 2004) and the value of -37 ppb found by Houweling et al. (2014). In Bergamaschi et al. (2009) the bias seems to be more latitudinally dependent during the winter months, as in our evaluation.

3.2 Specific comments

• *P2555, L12: Suggest that the authors update the reference to the latest version of the IPCC report, i.e. AR5.*

We updated the reference with Myhre et al. (2013). According to Table 8.2 in this report, the radiative forcing of the well-mixed Greenhouse Gases is $2.83\,\mathrm{W\,m^{-2}}$ in total. The methane contribution is $0.48 \pm 0.05\,\mathrm{W\,m^{-2}}$, that represents $17 \pm 1.8\,\%$. We updated the sentence with: "accounting for $17 \pm 1.8\,\%$ of the enhanced greenhouse effect (Myhre et al., 2013)."

• *P2555, L13: "hydroxide" refers the anion (OH-), whereas, what is meant here is the "hydroxyl" radical.*

We changed hydroxide by hydroxyl.

• *P2555, L14: From this sentence, it is not clear what is meant by "Its", do the authors refer to the impact of the concentration of CH_4 or to the oxidation by the hydroxyl radical. I suspect it is the former but it is not obvious.*

We changed the sentence with: "Methane fraction has increased substantially in the atmosphere since the pre-industrial period."

• *P2558, L25: How is "good enough" precision defined? Could the authors please explain?*

We changed the sentence with: "Currently the product can be used in the tropics only". More details on the precision are provided later on in the paper (page 2565, lines 7 to 13 of the discussion paper).

• *P2562, L14-15: The resolution of the CarbonTracker CO_2 mole fractions is not stated, however, the TM5 model used in CarbonTracker is at lower resolution than the that of the SCIAMACHY data and the MACC-II analysis system (T255). Therefore, using the CarbonTracker CO_2 to calculate xCH_4 requires either smoothing the SCIAMACHY data or interpolating the CO_2 mole fractions. It should be stated, which is used.*

The CarbonTracker CO_2 fields are $1° \times 1°$ degrees over North America and $3° \times 2°$ elsewhere. For each SCIAMACHY pixel, the CO_2 value in the nearest neighbour cell of the CarbonTracker grid is used to calculate xCH_4. This information was added in the revised version of the paper.

• *P2563, L22-23: The authors should state the resolution of the TANSO xCH4 product that was used in the assimilation.*

See the answer to the general comments.

• *P2565, L5-6: The authors should state the resolution of the IASI product that was used in the assimilation.*

See the answer to the general comments.

• *P2567, L20-24: I am confused by these sentences. The meteorological parameters were only replaced in the FREE experiment, was this also the case in the analyses? In the FREE experiment, were the meteorological parameters taken from a separate assimilation in which these parameters were optimized? Why was it not possible to have the same meteorological forcing in all experiments, and what are the possible implications of having different forcing?*

In the analysis experiments (SCIA, TANSO and TANSO+IASI), the meteorological parameters are analysed by the assimilation of all the operational meteorological data. At the beginning of each assimilation window (12 hours each) they are updated by the assimilation and then forecasted for the next 12 hours, and so on.

The FREE experiment consists of consecutive 12 hour forecasts in which the meteorological parameters are initialised at the beginning of the forecast with those from the SCIA analysis. On the other hand, the methane mole fraction is cycled from the previous forecast. This process generates small unavoidable differences in the meteorological parameters between the FREE experiment and the other experiments due to the computer precision in the input/output. The differences are quite small and we found that they have no impact on average. After further investigation, we believe that the observed difference in the stratosphere comes from the transport itself and not from the small differences observed in the transport (see below).

As the small differences in the transport are neutral on average, the information on these differences is not useful for the reader and we decided to suppress this information.

• *P2569, L13-15: It seems fairly logical that the SCIA experiment would still have lower xCH4 compared to the FREE experiment in winter, even when there are fewer observations to assimilate due to the time needed to re-adjust to equilibrium. Also it is clear that any difference with respect to the FREE experiment will be propagated with atmospheric transport. Therefore, these two hypotheses are equally valid and not independent from one another.*

We changed the sentence with: "This is due to both the transport that spreads the observation information in space and time, and the model adjustment to its equilibrium state."

• *P2570, L28: I am not sure how this statement supports the previous one. Could the authors please explain.*

The SCIA experiment has differences with the FREE experiment in the stratosphere. However, the sensitivity of the SCIAMACHY data is in the lower troposphere and the assimilation of these data should not impact directly the stratosphere. The differences found in the stratosphere could come from the transport, the background error vertical correlation or the fact that the meteorological parameters are not exactly the same in the two experiments.

A closer investigation leads us to conclude that the differences in the stratospheric methane are likely due to the transport. On average, the assimilation of SCIAMACHY or TANSO has for effect to add some methane in the tropics, in the troposphere up to 50 hPa. The tropospheric CH_4 increase is moreover advected to higher levels by deep convection that adds more CH_4 in the stratosphere. The stratospheric CH_4 increase is then advected at high latitudes by the meridional circulation in the stratosphere.

We removed "the previous" in the sentence as this statement was not issued previously. We also better explain where the differences are coming from with the following sentences: "Note that the difference between the TANSO experiment and the FREE experiment in the stratosphere is similar to the one between the SCIA experiment and the FREE experiment. This is likely due to the transport of higher CH_4 concentration from the tropics to high latitudes by the meridional circulation in the stratosphere. The CH_4 concentration is higher in the stratosphere over the tropics for the analysis experiments compared to the FREE experiment due to systematic positive increments in regions of deep convection (Figs. 7a and 7c)."

- *P2571, L8: The authors should emphasize that this is compared to the TANSO only assimilation (if that is indeed the case).*

We changed the sentence with: "The IASI+TANSO experiment has between 5 and 15 ppb less methane in total column after October 2011 than for the TANSO experiment".

- *P2572, L18: Do the authors mean that the global bias between each experiment and the observations was subtracted? If so, then this also removes the global offsets between each experiment. Therefore, it can only be the spatial gradients or relative differences that can be compared between experiments.*

We changed the sentence with: "We removed for each experiment the global average difference between the model and the measurements to better compare the spatial gradient errors between the experiments". In the following discussion only the differences between the gradients and the regional differences between the experiments are discussed.

- *P2573, L13: This is approximately the same bias as found by Houweling et al., for SCIAMACHY (-37 ppb) and should be referred to here.*

Houweling et al. (2014) are using the TCCON data to get this value of -37 ppb. We already referred to this study Sec. 3.5.2 when we compared the SCIA experiment with TCCON data. We believe it is the right place to provide the reference and we decided not to add it here.

- *P2573, L21: I suggest specifying that this is an underestimate of 7 ppb in FREE and 3 ppb in the assimilation.*

We did it.

- *P2576, L15: This is not sufficient to say that there is not a latitudinal bias in SCIAMACHY, in fact previous studies have found a latitudinal bias (e.g. Bergamaschi et al. 2009)*

We changed this sentence, especially regarding Fig. 11 of the revised version, with: "This indicates a larger latitude-dependent bias in the TANSO experiment compared to the SCIA one."

3.3 Technical comments

We made all the suggested technical corrections. For some of them, we slightly changed the proposed correction. We keep hereafter only the one we slightly changed.

• *P2556, L2: do the authors mean "inter-annual" rather than "internal"?*

Yes.

• *P2558, L25: replace "good enough" with "sufficient"*

We replaced 'good enough' by 'satisfactory'.

• *P2560, L2: remove the fullstop and join these two sentences*

We changed the sentence with: 'Methane mass mixing ratio is directly transported within IFS as a tracer and is subject to fluxes and chemical sinks'.

• *P2562, L5: I think the authors mean "dry air" and "mole fraction" (not "molar")*

We are now using 'column-average dry-air mole fractions'.

4 Figures

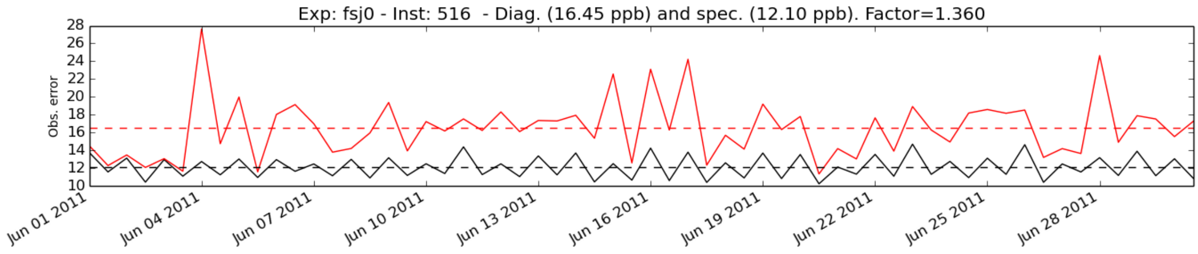

Figure 1: Time series of the mean observation error (in ppb) on the TANSO data per 12-hour assimilation window for June 2010. The observation error as given by the data provider is in black. The observation error as computed by posteriori diagnostics is in red. The dashed lines and the title of the plot provides the monthly average values for the observation errors (Diag. for the diagnosed value and spec. for the specified value) as well as the ratio between them.

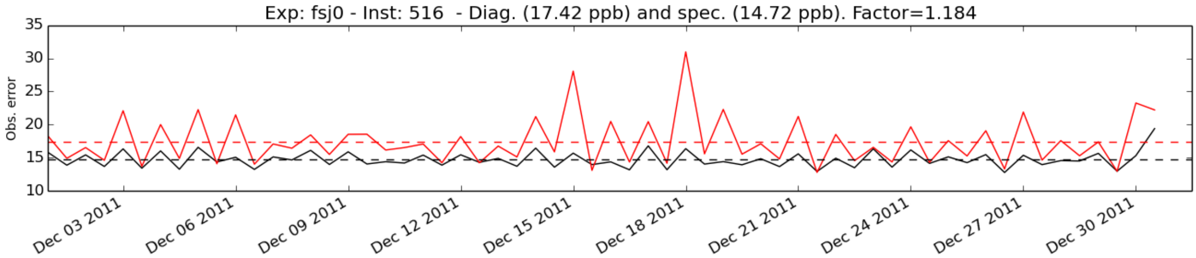

Figure 2: Same as Fig. 1 but for December 2011.

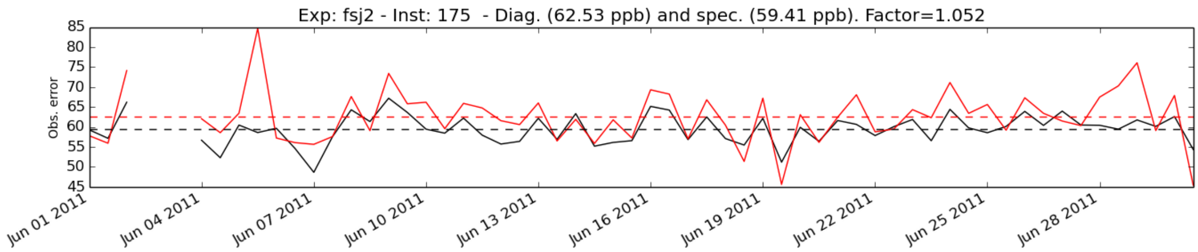

Figure 3: Same as Fig. 1 but for SCIAMACHY.

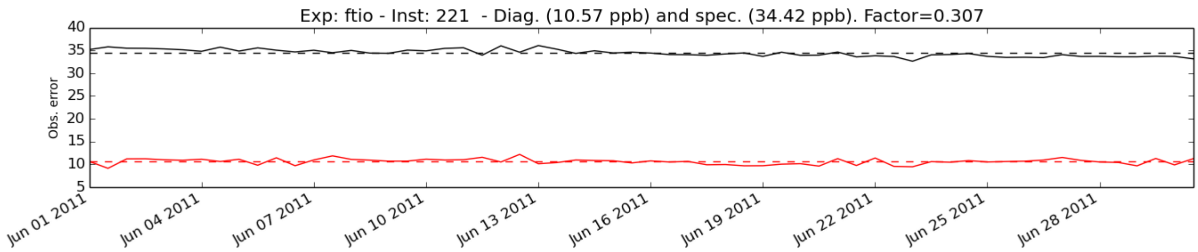

Figure 4: Same as Fig. 1 but for IASI.

References

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Parrish, D. and Derber, J.: National Meteorological Center's spectral statistical interpolation analysis system, Mon. Weather. Rev., 120, 1747–1763, 1992.

A TANSO data: version v.1 versus version v.2.0

To better examine the behaviour of the TANSO experiment during the change of the version of the assimilated data, we studied the month of October 2011 during which we had the two data sets (version v.1 and v.2.0). Figure 5 (left) presents the average gridded difference between the xCH_4 product of version v.2.0 and version v.1 for the whole month. Apart from East Europe the differences are small with both positive and negative values. On average, version v.2.0 has nevertheless higher xCH_4 values compared to version v.1, with a mean difference of 4 ppb. This difference drops to 2 ppb if we exclude latitude above $30°N$. This difference does not explain anyhow by itself the behaviour of the TANSO experiment. We thus made another experiment, referred to as TANSO.V.1 experiment, starting from the same initial condition as for the TANSO experiment on the 1 October 2011, but assimilating the version v.1 of the TANSO data (while the TANSO experiment was assimilating the version v.2.0 of the data from the 1 October 2011).

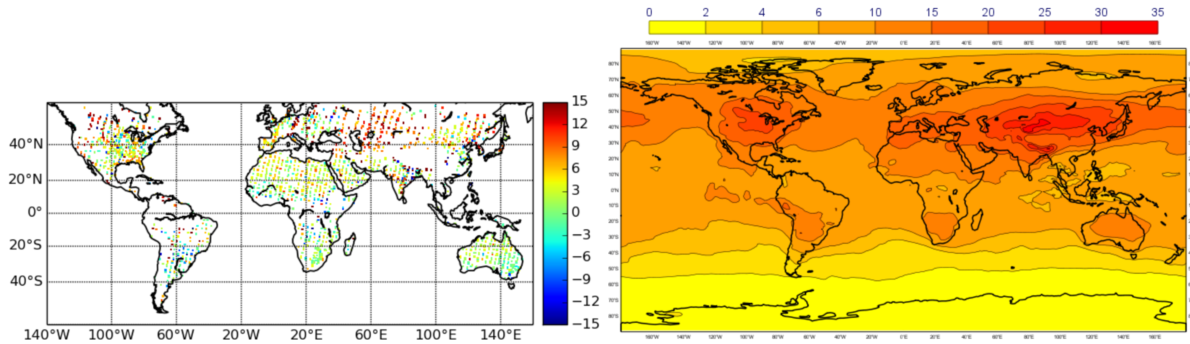

Figure 5: Left: average difference (in ppb) between the version v.2.0 and the version v.1 of the xCH_4 product from TANSO. Right: Dry molar fraction average column difference (in ppb) between the TANSO *experiment and the* TANSO.V.1 *experiment. The differences are averaged over the month of October 2011.*

We found that the average difference between the two analyses is on average 8.5 ppb (Fig. 5 Right) which is more than twice the difference between the assimilated observations. Even if the difference between the two analyses has a similar pattern as the difference between the two assimilated data sets (e.g. higher values over East Europe), the difference in the TANSO products can not explain the difference in the analyses.

The differences between the analyses come in fact from the averaging kernel information as illustrated by Fig. 6 (left). The two versions of the TANSO product provide a similar information (blue and red dots). The analyses of the two versions also provide similar information in the observation space (using the averaging kernel information, plain lines). In the model space (computing the molar fraction average column), the two analyses differ by about 20 ppb (dotted lines), the analysis of the version v.1 being lower.

We did the same but for the comparison with the TCCON data at Park Falls (Fig. 6 right). From the two analyses (TANSO experiment and TANSO.V.1 experiment) in the nearest grid point to Park Falls, we computed the columns (dashed lines). When a TCCON data was available, we computed the model equivalent using the TCCON a priori information. Then we computed the daily average of these quantities (small dots) as well as the daily average of the TCCON data (black dots).

As seen previously, the two analyses differ by about 20 ppb in terms of average column. When

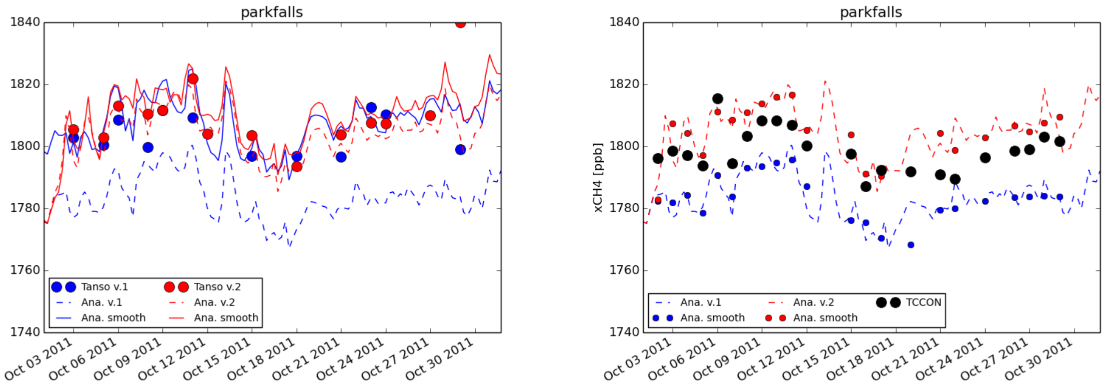

Figure 6: Time series of the TCCON, TANSO data and model data near Park Falls (45.945° N, 90.273° W). **Left***: the plotted TANSO data are the daily average of the data found within a radius of* 2° *around Park Falls: (blue dots) version v.1, (red dots) version v.2.0. The model data come from the nearest grid point of Park Falls. The dotted lines are the molar fraction average column computed from the analyses: (blue) analysis of version v.1 TANSO data, (red) analysis of version v.2.0. The solid lines are the smoothed columns using the data averaging kernel information: (blue) analysis of version v.1 TANSO data, (red) analysis of version v.2.0.* **Right***: Black dots: TCCON measurements. Dotted lines: molar fraction average column computed from the analysis of version v.1 TANSO data (blue) and analysis of version v.2.0 (red). Small dots: smoothed columns using the TCCON averaging kernel information.*

applying the TCCON a priori information, the difference remains the same. And the TANSO experiment compares better with the TCCON measurement than the TANSO.V.1 experiment.

In conclusions, the two versions of the TANSO data are similar even if the version v.2.0 has slightly highest values on average. The difference in the analyses projected in the observation space (using the averaging kernel information of the two version respectively) are also similar. But in the model space the columns differ substantially.