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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the consistency between global and regional methane emissions inferred from SCIAMACHY, TANSO-FTS, IASI and surface measurements" *by* C. Cressot et al.

Anonymous Referee #2

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General comments

The authors apply an inversion scheme to a number of observational datasets of atmospheric methane. Comparison of derived methane sources and sinks allows them to indirectly evaluate the consistency between these datasets. An interesting additional feature of this paper is the use of diagnostics for the variances of observation, background, and analysis errors, which allow tuning the background and observation error covariance matrices.

However, there are very serious issues with the paper, and major corrections are required to make the paper publishable. My main concerns are the following.

1. The conclusion on consistency between the satellite datasets is not justified. Even in the initial configuration with very conservative observation error settings, the global posterior fluxes do not agree within their respective uncertainties. With the tuned error covariances the posterior fluxes are simply inconsistent.

2. The transport model error estimates are completely irrealistic, leading to strongly overestimated observation errors, which is indeed confirmed by the tuning diagnostics. The basic inversions should be redone with realistic transport model errors of around 2% (Figure 7 can aid in making this estimate) instead of 8%.

3. The results of the inversions with tuned error covariances are ambiguous. This may be partly due to inaccurate reporting (see next point), but also because – as the authors state – one iteration may not be sufficient. However, the latter argument is used selectively for cases that do not satisfy the expectations. In any case, the conclusion that the quality of the fluxes is improved after tuning the error covariances is not justified.

4. The manuscript is very sloppy. There are countless inconsistencies between numbers in different parts of the text, and between text, tables, and figures.

Specific comments

P8025, L2 and furtheron: The term methane weighted atmospheric columns sounds strange (what is weighted?). I suggest changing to methane column mixing ratios.

P8026, L3-5: Some references demonstrating the use of inversions to improve both global and regional methane flux estimates would be appropriate here.

P8026: I am missing a clear statement on the goal of the study.

P8030: Some more explanation of the method of Desroziers et al. is needed. In particular, it should be made clear that Eqs. (5)-(8) are not equalities. The left- and right-hand sides are only equal if the error covariance matrices have been perfectly defined (and the tuning aims at moving towards this condition). Please explain also –

with equation(s) – how Eqs. (5)-(8) are applied to 'the ensemble defined by all observations'. I guess this is done by summing the diagonals? Next, clarify that the prescribed error variances are calculated by evaluating the RHS of Eqs. (5)-(8) [explain also how HBHˆT is evaluated], and the diagnosed values are calculated from the LHS. Then the ratio is introduced as diag/var, but in the remainder of the text, and in Table 3, the ratio is var/diag. This should be made consistent. Finally, isn't the 'full variance' the sum of the observation and prior variances?

P8031, L23: Is the production of OH obtained, or the concentrations?

P8032, L14: I guess fluxes should be columns.

P8033, L16: For MCF, we use the monthly variances . . . : to do what?

P8034, L4: The reflection of solar radiation is not (necessarily) weak at high latitudes.

P8033, L1-3: Please give typical values of observation and estimated transport error. This places the values for satellite columns into context.

P8034, L11: The mentioned reference Spahni et al. (2011) does not contain a justification for such large (8%) forward modelling errors. If modelling errors were really that large, I tend to conclude that there is no use for more accurate measurements. Indeed, the tuning procedure seems to indicate that these errors are far too large.

P8034, L23-25: Is it possible that CO2 columns derived from GOSAT are better suited for scaling GOSAT than SCIAMACHY CH4/CO2 ratios? Wouldn't it be more appropriate to use an independent CO2 estimate as light path proxy?

P8035, L14: Please motivate the 3% CTM error.

P8036, L7: Add that this increase is compared to prior fluxes (and omit that in L9).

P8036, L9-10: It is indeed expected that chemical losses are constrained by MCF observations. But this turns out not to be true. There are large variations in chemical loss between the different inversions (which all have the same MCF observations in-

cluded). Thus, the authors should remove the statement that CH4 losses are mostly constrained by MCF. In addition, a satisfactory explanation of why CH4 loss varies so much between the inversions is then also needed.

P8036, L19: Be consistent: the number 577 differs from 576 in Table 2.

P8036, L21-23: No, the emissions are not consistent. 578+-26 Tg/yr (SC_1ˆ1) is not statistically consistent with 531+-20 Tg/yr (IA_1ˆ1). Correct this statement.

P8037: This page is hardly readable with all these numbers. I suggest to make a table with the posterior fluxes and uncertainty reductions per region, and to demonstrate relationships between inter-inversion consistency and uncertainty reduction with reference to that table rather than introducing so many numbers in the text.

P8037, L23-25: Why is there a lack of IASI data during the monsoon period? If it is due to clouds, then why doesn't the same hold for SCIAMACHY and TANSO-FTS?

P8038, L13: 'Mean bias' sounds like a duplication, because 'bias' is already a mean. So please clarify that this is the mean of the biases for individual stations.

P8038, L17: Table 2 gives 27.0, the text 26.9 ppb mean bias for SC_1ˆ1.

P8038, L18-19: Please add these RMS numbers to the table. It would be even better to mention the standard deviation, since this is separated from the bias (unlike the RMS). And actually, a much better performance metric would be the RMS (or standard deviation) of the bias. While the mean bias over all stations can be small by luck and with large compensating errors, this is not the case for the standard deviation of the bias.

P8039, L13-15: See earlier remark on whether CH4 losses are constrained by MCF.

P8040, L15-18: The TANSO-FTS inversion growth rate is only marginally closer to that of the surface observation based inversion after bias correction. This rather seems a coincidence than a firm result of the bias correction. The reasons given for the fact

that the SCIAMACHY inversion growth rate gets further away from that of the surface observation based inversion after bias correction seem to be speculation. Unless proof is given, these reasons should be removed.

P8040, L23-24: Is 30.4 ppb comparable to 23.5 ppb? Still 30% difference.

P8041, L5: The ratio is here again defined diag/var, whereas Table 3 gives var/diag.

P8041, L9-10: The numbers 0.97 and 1.05 differ from the numbers 0.74 and 1, respectively, given in Table 3.

P8041, L10 and further: This is problematic, since the background error ratios actually get worse for the inversions with alpha=0.6 for both SCIAMACHY and TANSO. This is attributed to the fact that only one iteration is made in the tuning process. This seems unlikely: the ratios simply go in the direction one would expect (i.e. they become smaller), and since they were already quite good for the initial SCIA and TANSO inversion, they deteriorate with alpha=0.6. Furthermore, it seems that the argument of having only one iteration is made selectively for those cases that do not satisfy the expectations of the authors.

P8041, L13-16: For IASI the analysis error ratio actually gets worse (1/0.28 > 2.47).

P8041, L25: The number 9.23 should be 8.9 according to Table 3.

P8041, L26: The number 4.62 should be 5.53 according to Table 3.

P8042, L2-4: What motivates the choice gamma=0.075 for TA, while 1/8.9=0.11. Similarly, what motivates the choice gamma=0.175 for SC, while 1/4.53=0.22. Also, this experiment is not included in Table 3. And what motivates the choice gamma=0.33 for IASI, while 1/4.01=0.25?

P8042, L4: The number 0.27 should be 1.93 according to Table 3.

P8042, L5: The number 8.9 should be 9.23 according to Table 3.

P8042, L6: The number 1.07 should be 0.71 according to Table 3.

P8042, L6: The number 1.55 is missing in Table 3.

P8042, L9-13: How does one tune the observation error variance using the analysis error variance ratio? How does this lead to the choice of gamma=0.125 for TA? Is this a trial and error process? Please explain. And why does this alternative tuning process not work for SCIAMACHY and IASI?

P8042, L10: Should Eq. (4) be Eq. (8)?

P8042, L13: Where does the scenario SC_0.2ˆ0.6 come frome?

P8042, L20-23: The posterior global annual emission for TA_0.125ˆ0.6 is 568 (not 567) Tg according to Table 2. The global annual loss is 535 (not 545) Tg. Consequently, the mentioned growth rate is also wrong. The scenario SC_0.2ˆ0.6 is missing in Table 2.

P8042, L23-23: Is a growth rate of 27 Tg consistent with 19 Tg? That depends on the posterior error, which is not given.

P8043, L3: It's rather a 3-fold overestimation.

P8043, L17-20: I cannot verify this conclusion, since the final SCIAMACHY configuration is missing in the figure.

P8044, Section 4.4.3: As before, virtually all numbers mentioned in this section are either inconsistent with Tables 2 and 3 or cannot be verified since the respective scenario or statistic (rms) is not included in the table. Moreover, the conclusion that with statistical consistency of the inversion the fit to surface measurements is improved, does not hold for TANSO-FTS.

P8044, Section 4.5.1: Again wrong numbers. Why is TASU not included in Tables 2 and 3?

P8046, L8: Where does the number 526 Tg come from?

P8046, L10: On page 8039 the SCIAMACHY fit was 13.7*A_f-26.6 ppb.

P8047, L6-8: Where does 4.8 ppb come from? What is the meaning of '4.8 ppb of standard deviation' anyway? The conclusion on the improved fit to surface observations is wrong (see earlier remark).

P8047, L20: I don't see any data of Bouwman et al. (1993) mentioned in the paper. What is compared here?

P8048, L6-9: No statistics for the NH stations have been given. In fact, for the stations at latitudes below 50 degrees the RMS of the combined inversion was actually worse than the RMS of the TANSO-only inversion. The conclusion is thus not justified.

P8048, L21-22: Actually, without tuning the inversions with different observing systems are closer together. The tuning deteriorates the consistency between the inversions. This suggests that the posterior errors given by the tuned inversions are too optimistic.

P8049, 3-5: Why is SCIAMACHY not mentioned here?

P8049, 5-9: The final TANSO- and IASI-based inversions are statistically consistent with the surface observation based inversion, but not with each other. This may lead to problems if they are combined.

Table 1: Kaplan (2002) reports present-day global annual wetland emissions of 140 Tg, whereas Table 1 reports 177 Tg. Please explain.

Table 2: Explain in the caption what C_AF means. Add a column with the standard deviation of the bias with surface stations. Some scenarios mentioned in the text are not included in the table. Please include. Add the bias and RMS for the prior simulation and SU inversions.

Table 3: It's more logical to put the analysis error variance ratio in the last column. Include missing scenarios and missing numbers. Use same number of digits for all numbers in a column. E.g., write 1.00 instead of 1.

Fig. 2: Explain what is plotted here. Column-averaged mixing ratios? Averaged over a month? The caption suggests that monthly averages have been used in the inversions, but this is certainly not the case. Refine the color scale to show more detail.

Fig. 3: The final configuration of SCIAMACHY is missing in panel c. The error bars are missing for two inversions in panel d. Use one caption instead of separate captions per panel. The y-axis can be shrinked (say from 450 to 650) to show some more detail.

Fig. 4: The final SCIAMACHY inversion is missing in panel c. Use one caption instead of separate captions per panel.

Fig. 5: It's very hard to read these extremely small panels.

Fig. 6: What is 'too large'? And again, the panels are rather small.

Fig. 7: The fit line for SCIAMACHY (panel a) does not correspond to the fit results mentioned in the text. Also, please add the fit results in the panels. The density of points is not visible in the current plots. Please make scatter density plots.

Fig. 7 shows that SCIAMACHY has a negative bias compared to the reference surface observation based inversion. However, the SCIAMACHY-based inversions yield a strong increase in emissions. How can this be reconciled?

Fig. 7 gives an indication of observation errors, including transport errors. The standard deviation of model-obs differences cannot be accurately inferred from the figure, but it appears to be about 45 and 25 ppb (2.5 and 1.5%) for SCIAMACHY and TANSO-FTS, respectively. This standard deviation gives an upper limit to the observation error (incl. transport), because it also contains a component related to emission errors. Based on this figure it is clear that the assumed 8% observation error is far too large.

Technical comments

P8025, L24: spans -> is

P8026, L11: Atmosphere -> Atmospheric, ENVIronment -> ENVIronmental

P8027, L18: consists in -> involves

P8028, L29: consists in -> involves

P8029, L3: remove hyphen between inversion and members

P8029, L18: angle of view -> viewing angle

P8030, L15: applied on -> applied to

P8034, L23-26: Swap these two sentences.

P8035, L7: insert global between full and coverage.

P8035, L18: replace but with and.

P8037, L15: The surface ... the satellite ... Do you mean The surface observation based inversion ... the satellite data based in version?

P8039, L24: infers -> triggers?

P8040, L6L illustrates -> illustrate

P8041, L4: fairly -> fairly well

P8042, L23 and further: Statements like 'TANSO-FTS retrieves' are not correct. A satellite instrument does not retrieve something. Please reformulate. Also statements like 'IASI and the surface are in good agreement' and 'SCIAMACHY overestimates the growth rate' are incorrect.

P8043, L2: I in IA should not be italic.

P8048, L14: time exchange should be exchange time

Fig. 3: Do not use italics to denote the scenarios in the captions.

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