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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Inverse modeling of GOSAT-retrieved ratios of total column CH_4 and CO_2 for 2009 and 2010" *by* S. Pandey et al.

S. Pandey et al.

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We thank the referee for his/her useful comments. We have included the referee's comments (*italics*) and comments specific replies (AC) below. The corresponding changes made in the manuscript are written in blue below the ACs.

Anonymous Referee 2

The study by S. Pandey and coauthors reports inverse modeling experiments testing use of the GOSAT-retrieved ratio of methane and carbon dioxide column average concentrations for inverse modeling of both CO2 and CH4 surface fluxes. The manuscript does present new results of considerable interest, and can be accepted with a minor revision. Technical correction and proofreading is needed as there are many mistypes.

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Discussion paper

Detailed Comments:

*The ratio in hand is composed of 2 variables that vary very little around mean values. Linear expansion around mean state will transform the difference to a linear combination of XCO2 and XCH4, that is d(XCH4/XCO2)= (dXCH4-dXCO2*XCH4/XCO2)/XCO2. Given the ratio of column mean concentration around 400/1.7 ppm/ppm, XCH4 gets about 200 times higher weight in the linear combination of the two. Mysteriously, the ratio of the XCO2 and XCH4 errors is about same order (2/0.012 ppm/ppm), so the correlated parts of the errors are largely cancelled in ratio. On the other hand, ratio of surface fluxes is in order of 10/0.3=30 for anthropogenic (according to EDGAR data), and 9/0.2=18 GtC/GtC for natural fluxes (growing season net flux by Randerson et al. 1996; wetlands in Melton et al. 2013). Thus, we have ample imbalance of 6-10 times in favor of methane in terms of signal to noise ratio for sensitivity of XCH4 to XCO2 ratio to surface fluxes. Accordingly, use of a retrieved ratio for CH4 flux inversion is better justified than application for CO2 flux inversion. That makes results of this study interesting to look in. In particular, latitude dependent XCH4 bias contributed by combination of model (stratosphere) and retrieval biases comes in place of reduced aerosol and cloud effects. It would be useful to add discussion on the contribution of the methane XCH4 biases to CO2 inversion constrained by XCH4/XCO2 ratio.*

AC: We agree with the reviewer, however, there are some limitations to the calculation done above. In our inversions, we do not optimize anthropogenic CO2 fluxes. Also, the fluxes are weighted with their respective error in the cost function. We calculate the same number by adding a 1σ perturbation of global CH4 ($\approx$15Tg/yr) and CO2 (1.2GtC/yr) fluxes in the atmosphere. This will have the corresponding change in the mixing ratio of the tracers in the atmosphere. The change in CH4 mixing ratio will be (1800 ppb x (15 Tg.yr-1/5000 Tg))= 5.4 ppb.yr $^{-1}$ = 0.3%.yr^{-1} . For CO2, it will be (400ppm x 1.30 PgC.yr^{-1}/860 PgC)= 0.6 ppm.yr^{-1} = 0.15 %.yr^{-1}. So the Xratio will be impacted 0.3/0.15 $\approx$ 2 times more due to CH4 than CO2. As the inversion is adjusted

with the square of the observations, CH4 fluxes will be adjusted $2^2 = 4$ times more than CO2 fluxes. However, this number can be different on regional scales. As CO2 and CH4 surface data are assimilated also and both of them receive approximately equal weight in the inversion, the ratio may be lower. We have added the following to the revised manuscript:

"The signal from Xratio can be up to $\approx$ 4 times more sensitive to adjustment of CH4 fluxes than CO2 fluxes in our inversion setup. In such case, the surface observations of CO2 become the primary constraint on the CO2 fluxes. This can be further verified by looking at Supplementary figure 2, in which the RATIO and SURF inversion show very good agreement. It should be also noted that latitude dependent XCH4 bias contributed by the combination of transport model and retrieval biases become more important in a Xratio inversion while errors reduce due to aerosol and cloud scattering."

Technical corrections:

Page 01- Line 03 Putting here "biased" instead of "heavily biased" would suffice, referring to current state of retrievals.

02-17 and 02-25 Lists of papers are similar, likely to present same information twice, better to put some distinction. Adding Deng et al ACP 2014 and Maksyutov et al ACP 2013 may be useful for completeness.

02-31 "two types of retrieval methods" can be used in place of "two retrieval methods"

03-21 (Fraser et al., 2014) -> Fraser et al., (2014)

04-27 As- sessment -> Assessment

04-26 right spell should be v.4.2 FT2010

05-01 onJacobson -> on Jacobson

05-12 adding reference to Remotec (Butz?) would help here.

08-04 GOSAST -> GOSAT.

08-20 Should ppm/ppm be used in place of ppb/ppm?

09-01 Units of table 1 need more explanation. Text says it is percentage difference weighted with GOSAT+TCCON error, the value doesn't look like percentage.

25-01 inChevallier -> in Chevallier

28-31 In the reference list initials like A. are appearing as a. in multiple locations. AC: All technical corrections are addressed in the revised manuscript.

References. Randerson, J. T. and coauthors, Substrate limitations for heterotrophs: Implications for models that estimate the seasonal cycle of atmospheric CO2, Global Biogeochem. Cycles, 10(4), 585–602, doi:10.1029/96GB01981, 1996.

Melton, J. R., and coauthors, Present state of global wetland extent and wetland methane modelling: conclusions from a model inter-comparison project (WETCHIMP), Biogeosciences, 10, 753-788, doi:10.5194/bg-10-753-2013, 2013.

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