

## Point-by-point reply to review by Referee #2

By Xi Xi on July 6, 2015

We greatly appreciate Referee #2's timely review of the manuscript. Here we would like to provide a point-by-point reply to the comments. Each original comment is presented in italics, followed by the reply to each comment. The changes to the manuscript have been implemented in the revised manuscript. The page number and line number refer to those in the revised manuscript, which has been uploaded to the AMT Discussion Section.

**Comment:** *I agree with the very good and quite detailed general and specific comments of Referee#1 (R#1, C. Sioris) on manuscript "Simulated retrievals for the remote sensing of CO<sub>2</sub>, CH<sub>4</sub>, CO, and H<sub>2</sub>O from geostationary orbit" of Xi et al.*

*To avoid repetition I focus on listing some additional items I would like to see considered by Xi et al. for a revised version of this manuscript.*

*Abstract (page 5810):*

*I agree with R#1 that the term "retrieval biases" should be used instead of "retrieval errors" in the entire manuscript including the abstract as this would make clear that systematic errors are meant here and not random errors, which are quantified and discussed separately and called "precision" in the manuscript.*

**Reply:** It is agreed that the term "retrieval biases" is more appropriate for the discussions in this study. The term "error" is replaced with "bias" on P2L12, P2L15, P2L19, P12L10, P13L21, P13L24, P13L27, P15L30, P16L1, P16L2, P16L3, P16L8, P16L9, P16L11, P16L14, P16L16, P16L21, P18L13, P38L2, P39L2 and y-axis labels in Figures 7 and 8.

**Comment:** *Line 18: Please add at the end of the sentence: "and biases". The current sentence only refers to precision but biases are also very relevant in this context.*

**Reply:** The phrase "and biases" has been added. It is found on P2L19.

**Comment:** *Last sentence of abstract and corresponding discussion in paper: It is not clear to what extent co-located retrievals of XCO<sub>2</sub> and XH<sub>2</sub>O are useful "to better understand the close coupling between the carbon and water cycles" or if this would require to use altitude resolved (i.e., profile) information. This aspect should be better addressed in the paper and depending on the outcome the abstract needs to be adjusted (or not).*

**Reply:** It is agreed that this point needs to be better explained in the paper. The following sentences have been added to P5L4: "Because water vapor is the dominant greenhouse gas and its amount in the atmosphere is controlled by temperature, it constitutes a positive feedback on climate (Bengtsson, 2010). The co-located retrievals of these trace gases could provide more

information about how the amount of atmospheric water vapor might change when carbon fluxes change.” There are no prior studies that looked into this in depth, so we use the words “could” and “might” to indicate that there is a possibility that new information/insight could be provided by the co-located retrievals.  $X_{H_2O}$  is the total column water vapor, so it does not contain vertical information. At this point, it is unclear if vertical profile information is needed to see the connection between water vapor amount and carbon fluxes. With added explanations provided above, the sentence in the abstract should not cause confusion to the reader and thus is not adjusted.

**Comment:**

*Introduction:*

*Page 5811, line 10 and following: Do the two listed references only refer to land fluxes? If yes, please add a reference related to the mentioned first challenged, i.e., to “quantifying uncertainty in fossil fuel CO<sub>2</sub> emissions”.*

**Reply:** Yes, the two listed references mainly focus on land fluxes. A reference on “quantifying uncertainty in fossil fuel CO<sub>2</sub> emissions” is now added to P3L16.

**Comment:**

*Methodology:*

*Page 5815, line 10: Reference is made to the Crisp et al., 2004, OCO paper, but OCO also covers a strong CO<sub>2</sub> band at 2 microns to get information on the wavelength dependence of scatterers. GeoFTS however does not have this band. It appears that GeoFTS will not be able to provide information on the wavelength dependence of the optical properties (optical depth) of aerosols and cirrus and this may be a problem for accurate enough XCO<sub>2</sub> retrieval. This aspect needs to be discussed in the paper.*

**Reply:** It is agreed that GeoFTS will not be able to provide information about the optical properties of aerosols and cirrus clouds. The following sentence is added to P16L11 to emphasize the point: “Spectral measurements from GeoFTS alone do not provide enough information about the optical properties of aerosols and cirrus clouds.” Two ways to deal with this are discussed in P16L12 to P16L14. As shown in Figure 8, with increasing optical depth of aerosols and clouds, the retrieval biases get worse but the retrieval precisions are only slightly affected. This point is discussed in detail from P15L30 to P17L6.

**Comment:**

*Results and discussion:*

*Page 5822, line 7 and following: It is written that “This demonstrates that radiative transfer models dedicated to geostationary measurements can realistically simulate the diurnal variations*

*of radiances.” This statement is too strong given the limited amount of results shown and their qualitative discussion. Please replace “demonstrates” by “indicates”.*

**Reply:** The change has been made. It is now found in P12L24.

***Comment:** Page 5823, line 5: Has noise been added to the spectra? If yes, please add this information and also add how many noisy spectra have been generated and analyzed per case.*

**Reply:** Yes, noise has been added to the synthetic data. P9L10 to P9L13 describes the addition of noise. The sentence from P13L18 to P13L19 is now changed to “There are a total of 10 (locations)  $\times$  2 (days)  $\times$  4 (times of day) = 80 test cases and there is one simulated retrieval for each test case.” As one noisy spectra is generated and analyzed in each retrieval, this sentence tells the reader there is one noisy spectra per case.

***Comment:** Page 5823, line 12 following: Replace “our simulation results are better than those in real retrieval” by “our simulation results show smaller errors than those in real retrieval”.*

**Reply:** The phrase is now changed to “our simulation results show smaller biases and better precisions than those in real retrievals”. It is now found in P13L27.

***Comment:** Page 5824, last paragraph of Sect. 3.1: The radiance around noon should be higher than early morning and late afternoon resulting in better SNR and this should lead to better precision. However it appears that the other effects dominate leading to overall worse precision at noon. Is this correct?*

**Reply:** Yes, it is correct that the radiance around noon is higher than those at other times of the day. As SNR is kept constant at 300 for different times of the day, high radiances at noon implies higher noises. This causes the precision to be worse at noon. The value of SNR depends on the integration time when the measurement is made; it could be kept approximately constant if the integration time is adjusted slightly at different times of day. Also, as there is no validated way to model a diurnal variation of SNR from geostationary orbit, we assume a constant SNR in this study. One sentence “Note that these results are based on a constant SNR of 300 and in real retrievals SNR could be kept constant at different times of day if the integration time is adjusted.” has been added to P14L27 to clarify this point.

***Comment:** Section 3.3: What is the main reason that the precision improves for better resolution: Is it because lines are better resolved and there is less interference or is it because – for constant SNR – there are simply more spectral points available (each having the same SNR) as increasing the spectral resolution implies better sampling of the wavenumber / wavelength axis?*

**Reply:** The main reason is that for constant SNR, there are more spectral points available (each having the same SNR), so increasing the spectral resolution implies better sampling of the wavenumber axis.

***Comment:***

*Conclusions:*

*Page 5828, line 1: “We have performed simulated retrievals over a wide range of atmospheric and surface scenarios . . .”. “wide range” is too strong taking into account the quite limited number of scenarios investigated. Please replace by a less strong expression, e.g., use “significant range”.*

**Reply:** The phrase “wide range” has been changed to “significant range”. It is now found in P18L11 and also P8L1.