

# ***Interactive comment on “Bias assessment of lower and middle tropospheric CO<sub>2</sub> concentrations of GOSAT/TANSO-FTS TIR Version 1 product” by Naoko Saitoh et al.***

## **Anonymous Referee #1**

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The paper assesses biases in satellite-retrieved CO<sub>2</sub> concentrations at the lower and middle troposphere from GOSAT/TANSO-FTS TIR V1 product by comparing them with precise aircraft measurements by CONTRAIL CME, followed by global comparisons of bias-corrected CO<sub>2</sub> concentrations with model-simulated CO<sub>2</sub> by NICAM-TM. The authors found that the TIR data had negative biases of 1–1.5% against the aircraft measurements and bias-corrected TIR data showed generally good agreement with the NICAM-TM CO<sub>2</sub> data, which demonstrated the validity of the bias-correction values.

Observational CO<sub>2</sub> data in the free troposphere is still limited, and CO<sub>2</sub> profiles from high-resolution GOSAT TIR spectra will help to elucidate CO<sub>2</sub> variations in the free

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troposphere with its global coverage. Bias estimation of satellite-based CO<sub>2</sub> products is highly important for data users and further analysis of CO<sub>2</sub> fluxes by atmospheric inversion/data-assimilation studies. The paper is generally well written, and I recommend accepting it for publication after the comments listed below have been addressed.

## General comments

### 1. Results section.

The paper presents comparisons between the original TIR data and CONTRAIL CME data and between bias-corrected TIR data and NICAM-TM data. But the expressions of the evaluations are often qualitative, such as “relatively low”, “tend to be larger”, “slightly increase”, “nearly identical”, “close to zero” without any supporting numbers. Although one can see tendencies on the plots, I would recommend illustrating the point with some numbers and add a table with quantitative values to explain the results clearly. The authors do not need to write all related numbers, but at least it would be better to write statistic values related to Figure 7, one of the main plots, to show the validity of the bias-correction values quantitatively. Statistic values in a table or the main text may help readers to follow the discussion. They can be mode values (or medians), standard deviations, kurtoses and skewnesses of frequency distributions, the total number of data pairs, or whatever the authors need to describe Figure 7.

### 2. “East Asia” in abstract and discussion section.

The authors conclude that one of the reasons of the overcorrection in JJA/low latitudes (0S-20N)/upper MT region is that the correction values were determined by using the data over East Asian airports. Since the authors write this finding to the abstract, this conclusion is thought to be important for the paper. But the explanation (p.10, L34 - L11, L8) is not clear enough to understand why data in the East Asia region strongly affects to the 0-20N bias correction. Usually, Asia in 20S-20N is called Southeast Asia (or part of South India). Do the authors mean “Southeast Asia” rather than “East Asia”?

Or if the East Asian data truly affects the 0-20N bias-correction values via atmospheric transport, please give more explanation and references.

### Specific comments

p.3, Section 2, TIR data: Does the TIR product include nighttime data as well as daytime data? I suggest writing time of the observations briefly somewhere in this section.

p.4, Section 3, NICA-TM data: NICAM-TM inversion with CONTRAIL data was conducted for the period 2006-2008 (Niwa et al., 2012). It should be explained briefly how the 2010-2012 CO<sub>2</sub> data was calculated by NICAM-TM.

p.5, L24, “the number of pairs”: Could the authors show the number of pairs which finally used for the comparisons for each latitude bands?

p.7, L10, “On a global scale, the seasonality of negative biases was not clear, given the relatively large 1- $\sigma$  standard deviations, although these biases tended to be larger in the spring hemisphere than in the fall hemisphere.”: The sentence is not clear. Does this mean the negative biases had measurable spring-fall seasonality, but it was not statistically significant due to the large standard deviations? Or actually, the biases had no seasonality?

p.7, L26, “negative biases of TIR CO<sub>2</sub> data against NICAM-TM CO<sub>2</sub> data in all seasons slightly increased over time”: Is there no possibility that small trend error in NICAM-TM CO<sub>2</sub> could attribute the bias increase in Fig.7? The NICAM-TM natural fluxes were estimated for the period 2006-2008, which is different from the target period of this article. In other words, does the NICAM CO<sub>2</sub> have no bias in trends against CONTRAIL CME data? The authors can confirm it by plotting NICAM-TM CO<sub>2</sub> data against CONTRAIL CME data like Fig.6.

p.9, L5, other sources of negative biases: I’m not familiar with retrieval algorithms, but would any errors in cloud detection process cause retrieval errors in the low latitudes with enhanced convective activity? And H<sub>2</sub>O or O<sub>3</sub> do not affect the CO<sub>2</sub> retrieval

results?

p.10, L29-30, “The CME data that determined the bias-correction values of the 20°S–20°N latitude band were concentrated in East Asia”: I was confused with this sentence. Please see my general comment #2.

p.10, L34 – p.11, L1, “in most areas at 0°–20°N, and the negative biases were largest near airport locations in East Asia.”: Same as above. Please see my general comment #2.

p.11, L12-13, “More in-situ CO<sub>2</sub> data in the upper atmosphere in low latitudes”: Hiaper Pole-to-Pole Observations (HIPPO) project observed latitudinal distributions of CO<sub>2</sub> concentrations in the free troposphere over the Pacific Ocean where mostly clean during 2009 to 2011 (e.g. Wofsy et al., 2011). The dataset has been used for transport model or satellite data validation (e.g. Wecht et al., 2012; Kulawik et al., 2013). The comparison with HIPPO data is out of the scope of this paper, but if the authors found some problems in using HIPPO data for validation, please write it in the discussion section or the introduction section.

Wofsy, S. C. et al.: HIAPER Pole-to-Pole Observations (HIPPO): fine-grained, global-scale measurements of climatically important atmospheric gases and aerosols, *Phil. Trans. Roy. Soc. A: Math. Phys. Eng. Sci.*, 369, 2073–2086, doi:10.1098/rsta.2010.0313, 2011.

p.11, L17, “Reconsideration of the setting of retrieval grid layers ...”: Why do the authors think the current setting of retrieval grid layers might not be suitable for retrievals and reconsideration might solve it?

p.11, L20, “during the JJA seasons of 2011 and 2011”: Does this mean “2011 and 2012”?

Figs.3: The Y axis is described in altitude, not in pressure as seen in the following plots. For easy reference, I would suggest adding a 2nd Y axis in pressure or adding

a column in Table 1 to show altitude [km] for each pressure levels. (Rough altitudes from International Standard Atmosphere or the same kind might be enough for this purpose.)

Fig.4: Please replace “Altitude [km] in Y axis label with “Pressure [hPa]”.

Fig.7: I think drawing zero lines (i.e. no bias) in each panel makes the bias correction validity more visible.

Fig.7 caption “Thick and dashed lines indicate the biases of the original TIR CO<sub>2</sub> data (no bias correction) and bias-corrected TIR CO<sub>2</sub> data, respectively.”:

1. On my screen, all lines in each panel seem to have same line thickness. Do the authors mean “solid and dashed lines”?
2. This sentence does not match the main text which says that thick lines are bias-corrected values.

Fig.11, gray shade: Could the authors explain what gray zones in the figure are? (No data or out of color scale?)

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