

***Interactive comment on* “On the performance of satellite-based observations of CO₂ in capturing the NOAA Carbon Tracker model and ground-based flask observations over Africa land mass” by Anteneh Getachew Mengistu and Gizaw Mengistu Tsidu**

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Authors Response to Anonymous Referee #1 comments and suggestions on manuscript entitled “ On the performance of satellite-based observations of CO₂ in capturing the NOAA Carbon Tracker model and ground-based flask observations over Africa land mass ” by Anteneh Getachew Mengistu and Gizaw Mengistu Tsidu

We thank both Anonymous Reviewers, for their time and constructive comments on our

manuscript. These comments are very helpful to improve the quality of the manuscript and therefore we have carefully used them to revise the manuscript.

Comments: This is a very timely and very useful study of a much neglected problem – I strongly recommend publication. Scientific observation of CO₂ over Africa is extremely limited. Satellites watch the continent, but much of tropical Africa is under heavy cloud in the crucially important high-growth periods in the rainy season. On the ground in situ observation is minimal, and the few sites that are measured are mainly located on remote islands or around the continental periphery. Mengistu and Tsidu tackle this problem by examining the sensitivity and trustworthiness of GOSAT and Printer-friendly version Discussion paper OCO satellite measurements, tested against both the NOAA Carbon Tracker model and directly in comparison with the few available flask data sets.

Response: We thank the Anonymous Referee for his acknowledgment that our study is timely and useful. We hope that this study will bring attention to the regional study and strengthening the carbon network in Africa.

Comments: The paper is well thought out, detailed, and careful. There are some problems with the language but these are minor and there is full clarity of meaning. I strongly recommend publication after minor revision. Response: We have made some efforts to improve the language used in the manuscript and increases its readability. Specific Comments: Page 1. Line 20 – all over Southern Africa? Does this mean south of the equator? Or south of the Zambesi?

Response: In the main text we define the regions as: Northern Africa (100 - 350 N), Equatorial Africa (100 S – 100 N) and Southern Africa (350 - 100 S). However, we did not mention it in the abstract. Now we update the text in the abstract to describe the region boundary. Rightly so, southern Africa refers to a region south of Zambesi. Change is made on page 1 of line 21.

Specific Comments: Page 2 L4 – space after networks.

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Response: Change is implemented.

Specific Comments: Page 2 L14 – maybe give more mention to the TCCON station on Ascension Island. Contact D. Feist. <https://data.caltech.edu/records/210> I note that ASC is mentioned in table 1. Response: The TCCON station on Ascension Island is mentioned as an example of the TCCON stations. Change is made on page 2 of lines 18-21.

Specific Comments: Page 2 L35 onto P3 last sentence doesn't really mean anything. Also note that total column over many places includes very different air masses. For example over Ascension the air under the Trade wind Inversion is from the Southern Ocean and further, while the air above it is from the Congo, and ultimately further away.

Response: The statement on Page 2 L35 gives information that validation studies are important and had been also conducted by other researchers. It shows further that the results they have obtained at a global and regional scale elsewhere which will give the expected accuracies from our study. And Page 3 of the last line provides information about the TM5 model resolution on the global and North America which can give a clue for readers about the limitation of CT on a global scale as it has a sparse resolution due to the transport model used. These statements are now on page 3 of line 6 and page 4 of line 16.

Specific Comments: Page 3 L 1 – say where Kuwalik found this, geographically.

Response: The comparison study in the work of Kuwalik et al. was done using 17 different TCCON sites across the globe. We updated the text as "relative to 17 TCCON sites across the globe...". This change is made on page 3 of line 8.

Specific Comments: Page 3 L13 – African aerosol loading is very seasonal – very bad in biomass burning seasons. Response: Thanks for reminding us of the importance of seasonal aerosol loading's beside the geographical variation. We update the text as: "In addition, seasonal variation of biomass burning in Africa...." change is made on

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page 3 line 19.

Specific Comments: Page 3 L 30 – TM5 transport modelling – good. Explain in more detail.

Response: accepted and updated. See page 4 of line 17 "The model can be used in a wide range of applications, which includes aerosol modeling...."

Specific Comments: Page 4 L23 – maybe explain in more detail about the systematic error.

Response: accepted and updated as: "Chevallier (2015) shows systematic error in the African savanna associated with underestimating the intensity of fire during March at the end of the savanna burning season". This change is made on page 5 of line 10.

Specific Comments: Page 4 L25 – I think this means world's second, not 'second world' (i.e. Russia & China).

Response: thank you for noting this. Now it is corrected on page 5 of line 14.

Specific Comments: Page 5 Table 1 – Maybe mention the TCCON instrument Leicester have set up at Jinja Uganda (though it will be too late for this paper).

Response: Thank you for suggesting the newly established TCCON site in Uganda. This site will be a promising data source for future studies. We indicated the presence of this site in the introduction section of the revised manuscript as potential site that can provide data to bridge existing data gaps in the future.

Specific Comments: Page 7 L8 – southern part of Congo (does this mean Congo Brazzaville??? The southern Brazzaville Congo is similar to Kinshasa so I'm puzzled by that comment.) and then the text mentions Southern DRC....note the southern DRC is savanna, not forest, and has intense biomass burning in winter.

Response: It was the Congo Brazzaville to increase clarity we updated the text as: "some part of Equatorial Guinea and the Republic of Congo for CT (Fig. 1a) and part

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of Democratic Republic of Congo for GOSAT (Fig. 1b)" . This change is made on page 7 of Line 22.

Specific Comments: Page 7 L10 – I am very puzzled by the comment on “weak anthropogenic emissions” from South Africa, which has bigger CO2 emissions than either the UK or France. South Africa has some of the world’s biggest CO2 point sources including the enormous SASOL synthetic oil-form-coal plant and many >4GW coal-fired power stations. The ITCZ is critical of course, in two ways – it marks the effective boundary between the two meteorological hemispheres, and it also controls the vegetation uptake, as the plants grow under it, while the fires occur when it is in the opposite end of its range.

Response: Here we compare the Northern and Southern Africa (not South Africa). We agree that South Africa is the biggest fuel source and CO2 emissions from fossil fuels and cement production on continental wise. However, the aggregated emission from countries in Northern Africa like Egypt, Algeria, Nigeria, Libya and Morocco with a large contribution of CO2 emission exceeded South Africa. As a result, the aggregate emission of CO2 from the Northern part of Africa is more than that of Southern Africa.

Specific Comments: Page 7 L18 – year-round rainfall only near the coast in West Africa. Inland northern Nigeria is highly seasonal. The forest is only at the southern equatorial fringes of this band of countries. Response: Thank you we made them specific to the southern part of these countries. "southern Guinea, southern Ghana, southern Nigeria, southeast of Central Africa, ..." change is made on page 8 of line 5.

Specific Comments: Page 7 L29 – note NOAA calibrated measurements are ppm, NOT ppmV. Best to stick to ppm, even though there is only a tiny difference between ppm and ppmv.

Response: Thank you for noting this. It is a type error as noted in the x label of Fig. 2a it is in units of ppm not ppmv. It is now updated on page 9 of line 2.

Specific Comments: Page 8 L10 – annual mean position of the ITCZ – this is the meteorological hemisphere boundary. Might be worth expanding this remark.

Response: accepted and updated as "Position of ITCZ is the main climatic mechanisms controlling rainfall in Africa. Systematic errors due to ITCZ and the East African Monsoon need to be addressed well in satellite retrievals and modeling works." on page 9 lines 3-6.

Specific Comments: Page 8 L17 – model weakness? Or terrible satellite visibility when the ITCZ is present and clouds are extremely thick and widely present.

Response: Thank you for the suggestion, we updated it on page 9 of line 9.

Specific Comments: Page 9 L5 – “satellite own” ?? Typo?? Response: Revised as: "Satellite retrieval uncertainty" on page 10 of line 14.

Specific Comments: Page 10 L2 – Africa is one of the largest – rewrite as terrible English! I think this means it has more land on both sides of the equator than South America, but I’m not sure! Response: Thank you, this statement has been removed in the revised manuscript.

Specific Comments: Page 10 L4-13 – maybe move this entire paragraph to a place much earlier in the manuscript, to explain the focus on Africa?

Response: Thank you. We have now moved this paragraph to introduction as suggested on page 3 of line 21-33.

Specific Comments: Page 12 L15 – “simulation respond” - ??? does this mean response??

Response: It now reads "simulation is more sensitive to ... " on page 12 line 8.

Specific Comments: Page 13 L14 – sahara – it’s a desert! I have ĩńĆown over it many times. Not a weak source/sink – the vegetation is a nearly zero source/sink but there are very large ĩńĆaring operations in the Algerian and Libyan oil and gas ĩńĆelds.

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Those must be big emitters.

Response: It appears that the text did not convey the required message as our intention is to emphasize local emission. Therefore, we rewrote it as "This is mainly because Northern Africa is dominated by the Sahara desert, which is a vegetation-free area, and the systematic bias due to the local atmosphere biosphere interaction is minimum. However, the spatial mean of monthly mean bias is slightly higher (-0.36 ppm) over North Africa than over Equatorial Africa (-0.17 ppm) and Southern Africa (0.01 ppm). This is likely due to the presence of strong local emissions from Egypt, Algeria, and Libya as well due to long-range transport from the Northern Hemisphere..." on page 14 of lines 7-13.

Specific Comments: Page14 L13 – these are the winter & summer months for the Northern Hemisphere. Opposite in SH.

Response: We agree that it is good to mention that they are for the Northern Hemisphere and the opposite is for the southern hemisphere. Change is made on page 15 of line 10.

Specific Comments: Page14L18– winter (DJF) in Southern Africa???!!!! – Last time I heard it was high summer!!! Winter in the Southern Hemisphere is JJA. More to the point, the key factor for vegetation is the distinction between the rainy season (ITCZ present - growth) and the dry season (No ITCZ – ñÑres).

Response: Thank you for highlighting our silly mistake. It is corrected on page 15 of line 10.

Specific Comments: Page 16 L2 and L3 – maybe discuss this CT/GOSAT discrepancy in a little more detail? ITCZ cloud blocking observation??

Response: We hope that it has been discussed sufficiently on the next paragraph on page 16 line 8 - 18.

Specific Comments: Page17 L6 CT under estimation – interesting. Page 17 L18 – note

Northern Africa includes two very different biomes. North Africa (Morocco, Algerian coast, Tunisia) has a wet Mediterranean winter. The Sahara is desert but has big oil and gas fields, (including supplying Europe with winter gas).

Response: accepted and changes are made to highlight the differences between these places.

Specific Comments: Page 19 L3 – note that at the start of an El Nino there is often intense biomass burning. Later, the grass fires are smaller because there is no fuel.

Response: accepted and change is made to reflect this process.

Specific Comments: Page 23 L2 – Question mark in text??? Which region is the text talking about? – North Africa?? – if so, it is wet in the Algerian mountains in MAM. Fires are in summer. See also Line 4 in same paragraph. Response: Thank you. The question mark in the text is due to a missed citation in compiling the Latex. Now we include the reference. We know that regions of Africa have different burning seasons but the reference listed refers to the burning seasons of Africa in the context of the general areas in the north and south of the equator. Change has been made on page 23 line 16 and page 24 line 1.

Specific Comments: Page 23 L5 – “my cause”??

Response: Corrected as “may cause” on page 24 line 4.

Specific Comments: Page 23 L9 – plantation – well, maybe, but I flew over this a while ago and didn't see much! Note that Nigeria is very different from Egypt, and both are very different from Algeria!!! I think this paragraph needs substantial revision.

Response: Thank you for sharing your observation of the region. We updated the statement on page 24 of line 7.

Specific Comments: Page 25 L13 – note that grass fires dominate in the dry savanna, while leaf litter fires are common in the wetter wooded savanna.

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Response: Thank you for the suggestion. Our observation shows the discrepancy during the dry season and so it is most likely due to grass fires from the dry savanna. Now the text is updated in this sense on page 26 from line 9-10.

Specific Comments: Page 27 Section 3.8 and Figure 18 – maybe it is worth expanding this section 3.8 very significantly—it has real data!! Also note that these are boundary layer measurements. For example the Trade Wind Inversion (about 1500m in the Atlantic) is really important – ASC is below it, while IZO is well above it, so they sample completely different types of air mass (as noted in the last sentence of the section).

Response: We have tried out to further expand the discussion on this section 3.8. Page 27.

Specific Comments: General comment on the text Through the text there are many minor language problems. Some sentences are especially challenged grammatically. However, in contrast, many long sections read frequently and clearly. The language infelicities are many but small and not significant – the overall message gets through. The problems could easily be cleared up to make the work easier to read.

Response: Efforts are made to improve the language in the revised manuscript.

Specific Comments: AMTD Interactive comment Conclusion. This is a valuable and very interesting study. The paper should certainly be published, but it needs minor revision.

Response: Thank you for your recommendation of the work for publication in AMT.

Anteneh Getachew Mengistu and Gizaw Mengistu Tsidu

Please also note the supplement to this comment:

<https://www.atmos-meas-tech-discuss.net/amt-2019-390/amt-2019-390-AC1-supplement.pdf>

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