**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Improved simulation of group averaged CO_2 surface concentrations using $GEOS-Chem$ and $fluxes$ $from$ $VEGAS$" by $Z.$ $H.$ $Chen$ et $al.$

Anonymous Referee #1

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Any improvement in surface flux estimations from inversion models for regional and global scale models would be highly beneficial. In this work the Authors compare model surface fluxes with observations for different regions of the world, where the model has been ran once with existing emission inventories and once with a new emission inventory. The modelling method is sound and the data appear to be of excellent quality. However, the comparison with observations is limited by the measurement sampling and the modelling method used should be put into context with existing alternatives. The paper should be published after addressing a couple important general comments, a few specific issues and many technical corrections.

General Comments:

1) Most importantly, it is not clear that this approach is really beneficial. Whilst, this paper shows some improvements upon an existing inventory, it has many limitations in its method. There are alternative approaches, such as the assimiliation of satellite observations, that potentially offer vastly superior model surface fluxes without using the new inventory decribed in this paper. Given that this paper appears to try to show that the surface fluxes can be improved by using this approach, I would like to see the modelled surface fluxes of this approach compared to those of alternative approaches.

2) The results of this paper are very limited and biased by the number of observations in each region. It is almost meaningless to show results where there are few observations within a region, which is the case for many regions. Having said that, it is not your fault that there are few observations, and you should try to make use of what is available. The choice of region areas could be improved. While it is nice to show fluxes for the entire world, it is not practical or meaningful to do so with such few observations. It might be better to split the regions up into much smaller areas, for example Europe could be split up to have a region the size of Spain to Poland. Having a region this small would effectively reduce the sparseness of observations with a region and therefore make the model fluxes be more representative of the observations, making for a better comparison (even with few observations).

Specific Comments:

P2244, Line 11: Remove the sentence "Using the group averaged measurements of CO2 reduces the noise of individual stations.". This is not suprising if you average data.

P2244, Line 15: Please state clearly which observations were used for evaluating the results.

P2244, Line 24: currently we really need to understand source and sinks of a regional scale globally, not a global scale.

P2244, Line 26: Tans et al is a very old reference, there are many newer papers that could be used instead.

P2245, Line 8: This is not true, the whole world has been measured on a global scale using satellites, for example SCIAMACHY and GOSAT.

P2245, Line 9: Not necessarily for surface fluxes, becomes well mixed away from boundary layer.

P2245, Line 15: Discussed where?

P2245, Line 16: what samples?

P2245, Line 17: Either change to "previous studies have adjusted", or explain what inverse modelling is first, and then put "some inverse modelling studies"

P2246, Line 1: you need to introduce what GEOS-CHEM is.

P2246, Line 8: the sentence "it is significant....." doesn't make sense.

P2246, Line 9: Either explain inverse method or say using baysian theory and include a reference.

P2246, Line 10: you mention emissions from fossil fuel and have referred to this on numerous occasions throughout the paper, however fossil fuel emissions is too vague and doesn't include other sources created by humans. Please use "anthropogenic emissions".

P2246, Line 15: This should really be put earlier when its introduced.

P2246, Line 20: Please give full name for 3-h NEP.

P2246, Line 21: what do you mean? Is this for you rmodel as GEOS –Chem has been used for many purposes, and doesnt encessarily use that prior flux.

P2246, Line 25: When for? And use proper reference.

P2247, Line 6: make clear that CASA and VEGAS are separate.

P2247, Line 16: Remove the sentence "it can be downloaded...."

P2247, Line 22: Do we really need to know this? Consider removing.

P2248, Line 7: You state that VEGAS is for land, how is this used for oceans?

P2248, Line 8: Please include the source of data for observed precipitation and temperature.

P2248, Line 9: Explain fully what NBP flux means.

P2248, Line 11: Explain fully what NEP flux means.

P2248, Line 14: For what time frames etc?

P2248, Line 15: Poor grammar and needs quantifying.

P2248, Line 15: Largest sinks of what?

P2248, Line 17: What sources? Please specify.

P2248, Line 18: By how much?

P2248, Line 24: By how much?

P2249, Line 2: See earlier comment P2246, line 2.

P2249, Line 8: Give values for min and max.

P2249, Line 13: Which two land regions?

P2249, Line 16: "apparent" – please explain and quantify this.

P2249, Line 21: Explain why you say 72 sites – what are these?

P2249, Line 24: Aren't seasonal patterns of stations already well known? Put this into the introduction.

P2250, Line 4: Include a comment stating that photosynthesis and respiration depend on temperature and hence season.

P2250, Line 17: What do these different amplitudes mean?

P2250, Line 25: "it is helpful to distinguish when and where the sources and sinks are" – isnt this what you want to find out though? This doesn't make any sense.

P2251, Line 2: Be consistent with the use of sites/stations thoughout the paper. It would be much easier to read if you always used the word station.

P2251, Line 3: You need to be more precise in the way you describe trends. Please remove all "special trend" comments in paper and give a short description of the trend and how it is different than other trends instead.

P2251, Line 3: "The minimum appears in September or October" . Please just state one month – this should be the month where the minimum of the average trend lies within.

P2251, Line 14: I don't like the term "chaos". Please change this to something meaningful, for example you could say that there is a large variation between stations between January and June. Please also quantify this and also state how much the co2 increases by in the second half of the year.

P2251, Line 15: Don't say without average pattern, instead just say there is only one station in each region, and these stations show different seasonal cycles. Maybe also comment on whether any meaningful conclusions can really be drawn from this.

P2252, Line 5: Please reference a paper explaining GEOS-Chem, rather than stating a website in the text.

P2252, Line 15: Please state very cleary what you actually did. In my view, it is very unclear for what period and spatial scale the model was ran for.

P2252, Line 19: Again, change "patterns and amplitudes" to "cycles".

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P2252, Line 25: "The largest discrepancies for both runs appear in the region L11, which indicates there may be large uncertainties for co2 surface fluxes in Europe" - I am not at all convinced about this. Firstly, looking at the plots you can see that the difference between model results and observations is practically just as large for regions L7 and L8, i.e. the difference can be large for half of all land regions. Secondly, L7, L8 and L11 all have few and unevenly spatially distributed observations to compare against, whilst regions L1 and L2 have many observation stations distributed mostly over the whole regions. This can easily skew your data, and therefore the results are somewhat unreliable. This is well known to be a cause of large flux uncertainties. Thirdly, it is already well known that regions with few observations have large flux uncertainties and recent papers (some also using GEOS-Chem) have shown that the use of satellite observations can largely reduce these uncertainties, whilst ground based observations are limited.

P2253, Line 1: Please include values.

P2253, Line 5: "which suggests that more sinks in North America may be required for this period" - I have two issues with this statement. First, you should not say this. You should say that your model is overestimating the surface flux for this period. Secondly, there is also as large a difference, but for a longer duration, between june and september for region L1. Why do you only talk about november/december? I would consider june to september to be worse and this has a much bigger difference to the original inventories' results.

P2253, Line 6: "good agreement" – this is subjective. Please include much more quantification to back up your claims. Also I do not agree with L7 or L8 being in good agreement! These show large differences to the observations, as much as region L11. These are, however, much improved from the original inventories' results, so it would be good to talk about the improvement.

P2253, Line 10 and 11: It would be much clearer if you started the sentences with "In

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region 7..." and "In region 8...".

P2253, Line 19/20: Yes the ocean regions are influenced by land emissions, but the land is also influenced by ocean emissions.

P2253, Line 23: "great improvements" – what improvements? How much by? You really need to explain things more and include more quantification.

P2253, Line 24: "it can be deduced that the sources and sinks are improved in the South American Temperate though there is no direct observations in this region" – How is that deduced??? How can you prove this statement, when you do not even show any of the results for this region in the paper??? Given that this is stated in the ocean results section I can only assume you mean to suggest that the results in the ocean next to the region improve and therefore the land must too, but ocean and land do not behave the same so this can not be assumed, and these ocean regions do not dramatically improve either. If anything, this issue just highlights that the new inventory approach is very limited geographically.

P2253, Line 27: Please include some quantification, e.g. how big a difference? What time of year? Brief description of trend?

P2253, Line 28: It is not a persisting decrease from April. It only decreases between April and June. Also, the minimum for model results is not April, but rather in september according to your plot.

P2254, Line 2: "very complex" – This does not actually tell me anything. Better to say that the seasonal cycle has a large variation for stations in this region. This just shows how poor the comparison is for some regions, since if one of the stations was removed then the model results would either match perfectly with the observations or would be completely opposite to observations, depending on which station would be removed. Thus, it just highlights that the comparison is only really valid where there are many observation stations within a region (such as regions L1 and L2).

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P2254, Line 4: As mentioned previously, I do not think it is valid to compare ocean fluxes with land observations. The observations are highly influenced by local surface fluxes and very little by regional/global fluxes. Therefore it is not reasonable to compare land and ocean fluxes since they have very difference source/sink attributes.

P2254, Line 7: "more sinks may be required" – You should not say this. Instead just say that your model is overestimating the fluxes and not accounting for observed sinks. Can you comment on what might be the cause of this?

P2254, Line 8: "difficult to simulate" – Why is it difficult to simulate? Surely the model does not run any different in this region? It must be that the inventories are highly uncertain for this region.

P2254, Line 11: This is potentially not true though, as assimilation techniques using an ensemble kalman filter could be used instead with higher surface flux uncertainty reductions.

P2254, Line14: Comparisons to the root-mean-square difference – This whole section should be removed and should be incorporated into the previous sections where relevant.

P2255, Line 20: Appendix – this was confusing to read. Please separate into two paragraphs; one for the original inventory and one for the new inventory. Also, please reference the Appendix properly.

Table A1: Try to get this to fit on a single page. Also give the table a better description, with more explaination of what the stations are, etc.

Figures 2 and 3: Why do you only show just two months? It would be much more useful and justifiable to show a whole year (each month and yearly average) and each season (seasonal average).

Figures 5 to 9: Explain how these results were made briefly in the label, e.g. what year was the model ran for, what the observation stations are, etc.

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Figure 9: Combine three plots into a single plot.

Technical Corrections:

P2244, Line 5: The sentence "Observations at a single site..." is too long. Consider splitting up the sentence so that it reads better.

P2244, Line 8: Remove the word "site".

P2244, Line 14: Change "uncertainties" to "uncertainty".

P2244, Line 15: Please change sentence to say "We compared the group averaged values between model results with biospheric fluxes from the Carnegie-Ames-Stanford-Approach (CASA) and Vegetation-Global-Atmosphere-Soil (VEGAS) models, and used observations to evaluate the regional model results."

P2244, Line 18: At the start of the sentence please change to "The results".

P2244, Line 18: Change "the modelling" to "the modelled" or "modelling"

P2244, Line 19: consider rephrasing.

P2245, Line 11: rephrase i.e. CO2 in the atmosphere is affected by surface fluxes. Do not like the word "unbribable".

P2245, Line 17: Change "derive" to "aid determination of"

P2245, Line 22: put a comma after however

P2245, Line 25: Change to "points nearest to the site due to the lack of".

P2245, Line 26: change "in models" to " the model"

P2245, Line 26: change "proposed" to "propose"

P2245, Line 27: Change "checking" to "comparing"

P2246, Line 2: Consider rephrasing, e.g. "regional temporal characteristics of the

seasonal cycle which have been".

P2246, Line 4: Change "difference of" to "difference between"

P2246, Line 6: Add "located" at the end of the sentence.

P2246, Line 7: Replace "the CO2 emissions of fossil fuels are" with " atmospheric CO2 is"

P2246, Line 8: Change to "the global carbon cycle"

P2246, Line 12: Change "sink are produced" to "sinks have been produced" and remove "some"

P2246, Line 13: Change to "The GEOS-Chem". And Change "inverse" to "estimation"

P2246, Line 14: Change "it was used" to "it has been used".

P2246, Line 16: Change to " Nassar et al".

P2246, Line 20: Remove "balanced".

P2246, Line 23: Needs rephrasing.

P2246, Line 28: Change to "the VEGAS model was developed".

P2247, Line 1: Change "is introduced into GEOS-Chem model to replace" to "are used in the GEOS-Chem model, replacing"

P2247, Line 3: Replace "of this paper" with "describes the grouping of"

P2247, Line 4: Change to "demonstrates".

P2247, Line 10: Replace "an update" with "a".

P2247, Line 17: Replace "update" with "data product".

P2247, Line 18: Change to "observations".

P2247, Line 19: Replace "the data product includes extended records for the period" with "between".

P2247, Line 20: Change sentence to "where there are several measurements at different altitudes for the same site we only use the lowest in altitude. This gives a total of 108 measurements that have been used."

P2248, Line 1: Change to "the net ecosystem exchange (NEE) is simulated by the DGVMs and equals the heterotrophic respiration (RH) subtracted from the net primary productivity (NPP)."

P2248, Line 4: Change to "the DGVMs".

P2248, Line 16: Change "CASA about" to "CASA by about".

P2248, Line 20: Change "is shown" to "are shown".

P2248, Line 22: Change "and is replaced" to ", and are replaced".

P2248, Line 23: Change "work" to "study".

P2248, Line 23: Remove the word "obviously".

P2248, Line 24: Include a comma after GEOS-Chem.

P2248, Line 24: Change "is in" to "are shown".

P2249, Line 4: Change to "the seasonal".

P2249, Line 8: Change "groups in" to "groups on".

P2249, Line 9: Change "fall" to "autumn".

P2249, Line 10: Change "much more" to "greater". And change "stations in" to "stations on".

P2249, Line 11: Change to "the TransCom3".

P2249, Line 15: Change "of seasonal pattern and amplitude" to "in the seasonal cycle".

P2249, Line 15 and 19: Change "Ocean" to "ocean".

P2249, Line 19: Remove "then".

P2249, Line 20: Replace "grouped to" with "grouped into".

P2249, Line 21: Replace "the map" with "a map". Also change "sites" to "stations" – be consistent.

P2249, Line 24-26: Remove, as repeat of earlier section.

P2250, Line 5: Change to "studies have shown the seasonal cycle of atmospheric CO2...."

P2250, Line 6: Make reference an example i.e. (e.g. Randerson et al, 1997).

P2250, Line 6: Replace "of the magnitude for the amplitude, minimum values, maximum values" to "in seasonal amplitude".

P2250, Line 18: Change "o1,o6 is" to "o1 and o6 are".

P2250, Line 19: Change to "amplitude of groups O2 and O7 are much less than that of other northern regions.

P2250, Line 21: Replace "typically decreases moving southward" with "is less in the southern hemosphere".

P2250, Line 23: Start a new paragraph after the reference.

P2250, Line 28: Replace "trend" with "cycles of CO2 measured at".

P2251, Line 1: Change "the seasonal patterns" to "the CO2 seasonal cycle".

P2251, Line 2: Change "sites in South Pacific" to "stations within the South Pacific".

P2251, Line 5: Change "locate in South Pacific" to "located in the South Pacific"

P2251, Line 7: Change "minimal" to "minimum".

P2251, Line 10: Replace "patterns" with "cycles".

P2251, Line 11: Replace "pattern" with "cycles".

P2251, Line 12: Replace "pattern" with "seasonal cycle"

P2251, Line 13: Change "North Indian Ocean O12" to "North Indian Ocean (group O12)".

P2251, Line 14: Change "South Indian Ocean O13" to "the South Indian Ocean (group O13)".

P2251, Line 15: Change "(O10, O11)" to "(O11 and O11)".

P2251, Line 17: Change "The concentrations of CO2 of stations in ocean" to "The concentrations of CO2 at stations in the ocean".

P2251, Line 19: Change to "(for groups O4, O5, O10, O11 and O15)".

P2251, Line 22: Add "Inversely, " to the start of the sentence.

P2251, Line 22 and 23: Replace "austral" with southern hemispheric.

P2251, Line 23: Change "in the south" to "south".

P2251, Line 26: Replace "obvious" with "an".

P2251, Line 27: Remove rest of paragraph after the word February, and replace with "February, showing the seasonal cycle to be consistent for both hemispheres."

P2252, Line 12: Change "detail" to "detailed".

P2252, Line 13: Poor english grammar in the sentence "375 ppm for 1 January 2004 is set for a starting point of spin-up". Please change to something like "the model was ran using 375 ppm for the 1 January 2004 as a starting point".

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P2252, Line 15: Start sentence with "Figure 7 and 8 show..." and state what year and region(s)/global scale the model was ran for, and then say what the results are. Also, you can then remove the text in brackets from the sentence.

P2252, Line 19: Change sentence to say "CO2 seasonal cycles were simulated by the model with original and new emission inventories.

P2252, Line 20: Replace "discrepancy between model" with "difference between the model".

P2252, Line 21-25: Replace "runs" with "simulations" and "discrepancy" with "difference".

P2253, Line 1: Replace "discrepancy" with "difference".

P2253, Line 14: Start sentence with "For South America, Africa and Australia..." and change "scacity of" to "there are too few".

P2253, Line 17: Change "model" to "models".

P2253, Line 27: Change "for Indian Tropical" to "for the Indian Tropical region".

P2254, Line 6: Change "still large bias" to "still a large bias".

P2254, Line 9: Change "obviously" to "clear".

P2254, Line 10: Change "are needed" to "need".

P2254, Line 11: Replace "will be" with "can be".

P2255, Line 1: Change "sites" to "observation stations".

P2255, Line 2: Replace "observations" with "measured CO2".

P2255, Line 2: Change "The group averaged measurement values of CO2 concentration" to "the group averaged values".

P2255, Line 12: Remove the sentence "this implies possible ....".

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Figures 5 to 8: Replace "real line" with "solid line".