Interactive comment on "A synthesis of carbon in international trade" *by* G. P. Peters et al.

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Thank you for the useful comments. The following responses (in Blue) explain the changes we have currently made to the manuscript to respond to the comments. We have made modifications based on nearly all the comments. We will thoroughly work through the document again before resubmission to ensure it reads well and fully and consistently responds to the comments of both reviewers.

This manuscript describes physical and embodied transfers of carbon on a global scale. It synthesizes this information from several previous studies. The manuscript also includes new calculations.

The authors only address uncertainty in their work from the perspective of the spread in results from several studies. Uncertainty quantification from independent data is not an easy exercise in this case, but the authors do not address this issue at all.

- In the original submission we had a few sentences on uncertainty quantification, but we have now added a more detailed paragraph giving a summary of the key literature.

Overall, the scientific significance and scientific quality are rated as very good as the manuscript brings together a diverse set of literature as well as new calculations and presents them in a coherent manner.

The presentation quality of the manuscript is good. Suggestions for improvement are included below.

Detailed comments keyed to the manuscript:

page 3950, lines 16-17. We find that for embodied CO2 emissions estimates -> We find that for embodied CO2 emissions, estimates

- Fixed

page 3950, lines 17-18. differences between individual studies is not -> differences between individual studies are not

- Fixed

page 3954, lines 22-23. Within an MRIOT goods -> Within an MRIOT, goods

- Fixed

page 3955, line 15. European Commission et al., 2009 missing from references.

- Fixed

page 3955, line 18. European Commission et al., 2009 missing from references.

- Fixed

page 3955, lines 15-22. For final consumption, you list two end-consumers: government and individuals. Industry is seen as only an intermediary to supply the end consumers. Given this status of industry as an intermediary, why is government not treated in the same manner? Does government play a larger role than industry in supplying individuals and thus deserves status as an end-consumer? I would agree that government is a large consumer of goods and services and thus may merit separate tracking. But, by that same measure, is not industry not a large consumer of goods and services and thus merits separate tracking?

- It is conceivable to treat government as intermediate consumption, but this is rarely done. It is also possible to do simple reallocation of government consumption to households based on a per-capita. However, in general it is considered that there is no further processing after government consumption. Capital is a little more complex, and it is more common to reallocate to production. This section is now made a little clearer in relation to this.

  "Final consumption "consists of the goods and services used refers to consumption activities by individual households or the community government to satisfy individual or collective requirements needs or wants" (SNA, 1993). Final consumption usually consists of household and government consumption, and also gross fixed capital formation. Capital formation is restricted to institutional units in their capacity as producers, and refers to fixed assets that are used for more than one-year (SNA, 1993). Since fixed capital is ultimately to serve production, it is possible to reallocate fixed capital to intermediate consumption (Lenzen and Treloar, 2004;Lenzen, 2001), though this is rarely done."

page 3956, line 22. I see production, consumption, imports and exports existing in your framework. Section 2.1.3 describes the assumption that stock changes are equal to zero over a given year. What I do not see accounted for in your "country X" framework are bunkers. Bunkers refers to fuels used in international trade, that is the areas between clearly defined country X borders. In the embedded carbon concept how are bunker fuels as well as the supplies used in transport (e.g., food) allocated (e.g., to the shipper, receiver, flag carrier, ...)?

- Some further explanation was added on this point:

  "For environmental-economic accounting, bunker fuels used for international transport should be allocated to the country of the resident institute operating the vessel (European Commission, 2009).Thus, technically, emissions from bunker fuels should be correctly allocated to the territorial-based emissions, and then ultimately to final consumption via the international trade in services (Peters et al., 2011a)."

page 3958, line 2. oxidisation -> oxidation

- Fixed

page 3958, line 22. What is "protection" data? Do you mean production?

- Fixed, by adding "[tarrifs, quotas, etc]"

page 3958, line 24. In each region and each year the -> In each region and each year, the

- Fixed

page 3959, line 8. sector may mostly end -> sector may end

- Fixed

page 3959, line 9. sector may mostly end -> sector may end

- Fixed

page 3960, lines 17-19. I do not understand what this sentence means: “Since all the data is scaled by the carbon content, it is possible to scale the results up or down to represent different carbon contents.” I do understand that you have converted two types of wood from wet weight to dry weight and then to C content (the first phrase in the sentence). I do not understand the second phrase in the sentence where different C contents are invoked.

- Changed to “; though the results can be scaled up or down uniformly to give a different carbon content (e.g., 0.5t/tC)”

page 3961, lines 5-6. “requires additional calculations.” Are these additional calculations done in this study? The text is not clear on this point.

- Added “…which are discussed later”

page 3962, line 20. different to the -> different than the

- Fixed

page 3963, line 29. controlled for to -> controlled to

- Fixed

page 3964, lines 15-17. Four items: 1) Table 1 does not specifically link regions and countries, rather it states growth rates in particular areas. So, line 15, rates between key -> rates of key. 2) Also, this sentence reads awkwardly with the use of ‘shows” and ‘showing”. Please rewrite to clarify. 3) The column title states “Consumption growth rate” in Table 1, yet the text compares ‘consumption-based emissions” and “consumption”. I only see one value given here so I do not see the both sets of data upon which the comparison statement is made. 4) Finally, given the extensive discussion of consumption definitions in section 2.1.1, which type of consumption is represented in Table 1?

- All these issues have been fixed. The problems were mainly due to poor language. The main text now reads

  “Table 1 shows the growth rates of production- and consumption-based emissions for key regions and countries. In general, consumption-based emissions in developed countries are growing faster than production-based emissions, with the opposite holding in developing countries. ”

page 3966, line 8. European Commission, 2009 missing from references.

- Fixed

page 3969, line 14. What are “outliner” sectors?

- This was a confusing and unnecessary word, and has now been removed.

page 3969, line 23. then -> than

- Fixed

page 3975, line 7. variables ...(Peters -> variables (Peters

- Fixed, it was a mistake in the proof

page 3979, line 27. region -> regions

- Fixed

page 3980, line 4. Figure 12 is called in the text before figures 10 and 11. Please renumber.

- Fixed

page 3983, line 2. MtC),North -> MtC), North

- Fixed

page 3984, line 9. simply be down to chance -> simply be chance

- Fixed

page 3986, line 19. reports -> report

- Fixed

page 3986, line 23. primary -> primarily

- Fixed

page 3987, lines 24-25. Perhaps a few more words are needed here in terms of “balancing regional carbon budgets”. I think you are writing this in the context of atmospheric inversion studies. If so, attention would also need to be placed upon the oxidation rates of these carbon flows and the time interval of the inversion. For example at the annual time scale typically used for inversions, fossil fuels are assumed to be oxidized. However, for example, for the carbon flows discussed here, wood products have a very different oxidation rate.

- We have now turned this into a separate paragraph.

page 3989, line 17. I am unsure exactly what your trying to say here; “the greatest need to for further research is to identify ”. I think there is an extra word (e.g., “to” or “for”) in the phrase.

- Fixed

page 3990, line 2. associate -> associated

- Fixed

page 3991, line 21. An updated version of the Andres et al. reference can be found on the BG website. The manuscript has moved from BGD to BG.

- Fixed

page 3993, line 3. European Commission, 2009a not cited in text.

- Fixed

page 3993, line 6. European Commission, 2009b not cited in text.

- Fixed

page 4000, line 4. "The CDIAC global total does not include bunker fuels." I am confused by this statement. Do you mean the total reported in this table does not contain bunker fuels? The global total reported by CDIAC typically does contain bunker fuels whereas their sum of countries does not.

- Clarified with "…as we take the sum of the country totals excluding bunkers"

Also, in Table 2 you state that CDIAC has bunker fuels in their global totals.

- Clarified with "(but included…)"

Also, does a positive % value indicate a value greater than or less than the CDIAC value?

- Added "(positive is greater than CDIAC)"

For the top 10 differences section, differences in terms of what variable? I do not see a consistent ordering of values for any of the five metrics reported here.

- Added: "The "top 10 differences globally" are sorted by the range in estimates; maximum minus minimum."

page 4002, table 5. Does a positive % value indicate a data set is greater than or less than CDIAC?

- Added "(positive is greater than CDIAC)"

For the top 10 differences section, differences in terms of what variable? I do not see a consistent ordering of values for any of the five metrics reported here.

- Added: "The "top 10 differences globally" are sorted by the range in estimates; maximum minus minimum."

page 4012, figure 1. The caption listing the various symbols used and associated studies is very small in size. This needs to be enlarged.

- Noted. We expect the figure to be larger in the BG format and we will check this at the proofing stage.

Have you thought about putting all the data onto a y-scale that includes zero? Or onto the same y-scale with the same min and max values? This would flatten the appearance of year-to-year variation, but it would make it easier to compare data from two different areas.

- Yes, we did think of this. Certainly, this makes the variations look much smaller. If everything has the same scale then everything will look small relative to China. Note, however, that the left and right figures each have the same scale (max and min) to allow country comparisons. Since we are discussing the differences, we want to highlight them, and hence we keep the scale the as is.

- We clarified by adding to the caption: "Each country has the same scale for production and consumption. The minimum value has not been taken as zero to highlight the differences, but relative to national totals, the differences are small (Table 5)."

page 4013, figure 2. There is a lot of information here. Unfortunately, the x-axis country names are so compressed together that it is difficult to read them.

- We have fixed this by including less detail

Also, does a positive % value indicate GTAP is greater than or less than GTAP+NAMEA?

- Added to caption "Positive values indicate that "GTAP" is larger."

page 4014, figure 3. There is a lot of information here. Unfortunately, the x-axis country names are so compressed together that it is difficult to read them.

- We have fixed this by including less detail

Also, does a positive % value indicate GTAP is greater than or less than EDGAR?

- Added to caption "Positive values indicate that "GTAP" is larger."

page 4019, figure 8. Great diagram. It would be improved if the numbers were made larger for easier reading.

- Noted. We expect the figure to be larger in the BG format and we will check this at the proofing stage.

page 4020, figure 9. Another great diagram. It would be improved if the numbers were made larger for easier reading.

- Noted. We expect the figure to be larger in the BG format and we will check this at the proofing stage.

page 4022, figure 11. 200 ->200x. Missing digit from year.

- Fixed

page 4023, figure 12. Larger font size for numbers would be useful.

- Noted. We expect the figure to be larger in the BG format and we will check this at the proofing stage.