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## ***Interactive comment on “Anthropogenic carbon distributions in the Atlantic Ocean: data-based estimates from the Arctic to the Antarctic” by M. Vázquez-Rodríguez et al.***

**Anonymous Referee #1**

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### **Summary**

Vazquez-Rodriguez et al. present the results of an intercomparison of 5 recently developed methods (or sub-methods) to reconstruct the concentration of anthropogenic CO<sub>2</sub> in the ocean. On the basis of 4 representative cruises in the Atlantic Ocean, they find that while these methods give relatively similar overall inventories, the spatial distribution of the reconstructed anthropogenic CO<sub>2</sub> differs substantially. The Southern Ocean emerges as the region with the largest differences, but also substantial depth dependent differences were identified in many other regions.

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## Evaluation

With only two of the four major terms of the global anthropogenic carbon budget since the beginning of the industrial period being well established, i.e. the fossil-fuel emissions and the atmospheric CO<sub>2</sub> accumulation, any additional constraint on the remaining two components, i.e. ocean and land uptake is of particular relevance. Sabine et al. (2004) provided such a constraint for the global ocean on the basis of a  $\Delta C^*$  based reconstruction of the global distribution of anthropogenic CO<sub>2</sub> in the ocean. In the last few years, several additional methods have been developed, but so far, no systematic intercomparison of the various methods has been conducted.

In this manuscript, Vazquez-Rodriguez and co-workers undertake a first attempt at such a systematic intercomparison, thereby filling in a clearly identified need. As such, this paper is fundamentally well suited for publication in Biogeosciences and likely will attract good readership. But before I can recommend acceptance of this manuscript, the paper needs to be much improved and expanded. As it stands right now, the manuscript is little else but a presentation of a few key results. This is clearly insufficient for a publication in Biogeosciences, as the manuscript does not contain a discussion with substance nor does it provide a clear roadmap for how the identified differences can be reconciled and improved upon. I am fully aware that this is a difficult task for any intercomparison paper, but this is not an excuse for not making an attempt.

I have the following four specific recommendations for how the paper can be improved:

- i) Provide detailed statistics on the distribution. For example, plot the Cant estimates of the various estimates against each other and discuss where the largest differences occur. Compute correlations etc, offsets, etc.
- ii) Evaluate the different estimates in comparison to other tracers, particularly pCFC (don't plot against [CFC], but against pCFC!), but consider also temperature.
- iii) Discuss the reasons for why the different methods arrive at these various estimates.

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What are the particular assumptions that lead to these distributions?

iv) Provide a roadmap for how we can arrive at improved estimates of anthropogenic  $\text{CO}_2$  in the ocean. For example, it is particularly intriguing to use the change in Cant, Delta Cant (for example by differencing two occupations) as a constraint, since model simulations as well as theoretical approaches (see for example the discussion in Tanhua et al.) clearly show that Delta Cant and Cant are rather strongly related to each other.

I could think of more analyses (e.g. plots of Cant versus (pCFC) age on isopycnal surfaces) etc, that would help to understand similarities and differences.

A second major comment I have concerns the English language. There is much room for improvement as well!

## Recommendation

This is a potentially interesting paper deserving publication, but it is currently too weakly developed to merit a positive recommendation. I therefore can recommend acceptance only after a major revision.

## Detailed comments

Abstract and elsewhere: Extrapolation: I find it overly ambitious to extrapolate estimates that pertain to a single set of sections to the entire Atlantic. I am particularly concerned in the subpolar North Atlantic and the Southern Ocean, where there are substantial east-west differences. I am aware that the authors attempted to take this into consideration, but what is the basis for the argument that all methods have the same scaling to the  $\Delta C^*$  based estimates? Isn't it very feasible that an overestimate

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in one part of the ocean corresponds to an underestimate in another part? I therefore think that the total inventories need to be presented with much more caveat and uncertainty than they are presently associated with.

Introduction and elsewhere (lines 17-21). The writing needs to be much improved. I take the following two sentences as an example:

"International effort has been focused to investigate the evolution of the oceanic sink of atmospheric CO<sub>2</sub>, and to understand how human activities interfere in this air-sea coupled system. The endeavour aims at gaining insight on the assessment of the future possible scenarios proposed by the Intergovernmental Panel on Climate Change (IPCC Fourth Assessment Report: Climate Change 2007)"

i) "has been focused": wrong tense. ii) second part of sentence is not well linked with first part of sentence. iii) "insight on": should be "insight into" iv) "endeavour aims at gaining insight on the assessment of": this can be shortened to "The goal is to assess" etc, etc.

Introduction, p1423, line 17: If I recall correctly, the fraction is 45% not 50%.

Introduction, p1423, line 25: It might be worth mentioning that the oceanic inventory does not only provide a constraint for (forward) ocean models, but also constitutes a key input for inverse estimates of the ocean fluxes of anthropogenic CO<sub>2</sub> (e.g. Gloor et al., 2003, Mikaloff Fletcher et al. 2006; Gerber et al., submitted) as well as for global carbon cycle budgets as presented, for example, by IPCC.

Introduction, p1424, line 21: "validate". I doubt that such reconstructions can be used to "validate" models. However, they serve as useful estimates to "evaluate" the models.

Method, p1426: I suspect that more details are needed here in order to have the background needed to discuss the reasons for why the estimates differ.

Results, p1426, line 13: adjustment to common year: Please specify whether this

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was done for each method separately, i.e. using the Cant estimate of that method, or whether the same adjustment was used for all estimates?

Results, p1426, line 22: setting conc. to zero: I am concerned with this procedure, as it will lead to biases in the inventories. I highly recommend to consider all observations (negative and positive).

Atlantic inventories, p1431, line 17: As noted above, I am concerned with this extrapolation. It is not unreasonable, but it introduces a significant amount of uncertainty into the basin-wide inventories. These need to be properly acknowledged and discussed.

Figures: The figures are of good quality (they will have to be printed fairly large), but they are all of qualitative nature. See my suggestions above for suggestions.

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