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***Interactive comment on* “Estimating carbonate parameters from hydrographic data for the intermediate and deep waters of the Southern Hemisphere Oceans” by H. C. Bostock et al.**

Anonymous Referee #1

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Review of "Estimating carbonate parameters from hydrographic data for the intermediate and deep waters of the Southern Hemisphere Oceans" by Bostock et al.

This study exploits the wealth of hydrographic and oxygen data to enhance the distribution of carbonate variables and derived parameters in the southern hemisphere oceans. The technique appears to work fine, though I would like to see some more discussion as to the caveats.

The manuscript would need some rephrasing as at some places the discussion is not careful enough. Some hints for this are given below, but the authors are advised to go through the remaining manuscript as well.

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Section 2 and large parts of the discussion are not understandable without a proper map of the southern hemisphere/Southern Ocean, with names of basins, currents and topographic features mentioned in the text.

Section 3. It is not clear to me whether the authors used available data or performed recalculation and quality control themselves. For example, they write that the alkalinity is calculated using Mehrbach constants. Did they do that or were all available data calculated that way? Were original data (as published by the data originators) used or data with adjustments like in the data products GLODAP and CARINA/PACIFICA? I think some more detailed information on the data origin is needed.

In Figure 3 it can be seen that the residuals do not show a Gaussian distribution. In particular the deeper values are relatively strongly overestimated. Although this is mentioned in the text, I am missing a (quantitative) discussion what this means for the derived parameters like the saturation states and the CSH and ASH.

Apart from CARS, there is the much used World Ocean Atlas. Why has CARS been chosen and not WOA? Please add a few words about this to the manuscript. Please provide at some point definitions of residuals, $\Delta\epsilon_{\text{aragonite}}$ and $\Delta\epsilon_{\text{calcite}}$ and CSH and ASH. Please take care also to describe all fronts before using the abbreviations. Actually, the many abbreviations used are strongly reducing the readability. Please consider not to use that many abbreviations, or only few that are common.

Minor and technical comments P6226 line 21-22 "... CLIVAR/CO2 Repeat Hydrography Program, also known as CARINA/PACIFICA (2000's; Tanhua et al., 2008; Sabine et al., 2009)." This is not right. CARINA and PACIFICA are fully independent of CLIVAR. Both are data rescue and quality control efforts like GLODAP, where the number of cruises and stations has been enhanced compared to GLODAP by a factor $\times 10$. Moreover, CARINA and PACIFICA have data from all years, not only from the 2000s.

P6227 line 3 phenomena P6227 line 9 If it were possible ... P6228 line 1-2 Most MLR studies mentioned have not focused on surface waters, but rather on deep waters. On

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the contrary, it is not always possible to use an MLR for both surface and deep waters.

P6229 line 14 "in most of" instead of "in the majority of"? P6229 line 10-11 It reads awkward when plural is used for the abbreviations of the water masses. Later at this page it is not done anymore, but it does also occur later in the manuscript. Please change this.

P6229 line 20 delete "back" P6229 line 26 delete "some" P6229-6230 "These waters ..." Which waters are meant here? P6231 line 1 Ganachaud P6231 line 8 Fig2 does not seem to be appropriately cited here. P6231 8-10 "We used all the data south of 25° S and deeper than 200 m, as the intermediate and deep water masses formed in the Southern Ocean lie beneath the subtropical gyres." I do not understand what this sentence is trying to convey. Did you actually only use data below 200 m? In Fig. 1 it seems that all data were used. Please explain.

P6232 line 10 "two" instead of "several" P6232 line 12 I do not understand the use of "therefore" here. I tend to think, just because there is a difference, one should apply a correction. Please elucidate.

P6232 line 15-19 "...with only 5–10 $\mu\text{mol kg}^{-1}$ changes in DIC estimated between 200–1000m (Sabine et al., 2008; Sallée et al., 2012). This is small relative to the natural variability in the oceans and of similar order of magnitude to the combined uncertainty associated with the measurements ($\pm 2 \mu\text{mol kg}^{-1}$ when using a CRM) and our algorithms." What kind of changes are meant here? Is natural variability in the intermediate and deep waters meant here? I think the deep water variability is not that large. If the authors know of such variability, please give references. Earlier in the section the accuracy of DIC was said to be $3 \mu\text{mol kg}^{-1}$ and moreover, all data were said to have used CRMs. This is right, isn't it?

P6233 line 7 The equations need a number, right? P6233 line 11 and further: Fig. 3 should be cited here (as it is not done elsewhere) Please explain why there are two distinct regimes the way you define them. More regimes might be discerned as well.

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How good is the fit, and how much has it been improved?

P6234 line 1 For further analysis . . . P6234 line 2 delete "is" P6234 line 14, 23 "versus" instead of "v" P6234 At some point, please describe how residuals are defined. P6234 line 15, 21 Please explain how you come to these contentions. P6234 line 29 Largest residuals at 200-500 m, but only in the south! P6235 line 1 Fig. 3 should also be cited here. I would put the boundary at >2500 m. P6235 line 10-11 "South of the PF, the MLR overestimates alkalinity (and DIC to a lesser extent) in the upper 1000m (Fig. 4)." This is not the whole story. The MLR overestimates alkalinity (and DIC, except near the bottom) in the entire water column.

P6235 line 20-21 Why is this contention done at this place? Are the oxygen data referred to spurious? In that case, they should be discarded.

P6235 line 26 Silicate (not silica) and phosphate are particularly high in the Southern Ocean and therefore it surprises me that they are neglected. Moreover, there are large gradients between the Southern Ocean and the waters equatorwards of that, which might introduce artifacts in the spatial distribution. Please provide evidence for your contention by way of the calculated contribution by common Southern Ocean silicate and phosphate concentrations to the computed parameters.

P6236 line 8-9 "... allows us to estimate the distribution of alkalinity and DIC where only hydrographic data has been collected" This sentence is apt to confusion. Change to: "... allows us to estimate the distribution of alkalinity and DIC at all locations where hydrographic data has been collected".

P6236 line 26 Define EqPIW. P6237 line 5 Add "as" after "procedure" P6237 line 10-13 (and also the "In contrast" after that) This example is not clear to me. Please explain.

P6237 line 18 Define STF. P6237 line 23 Add ; (semicolon) after "oceanography", since the sentence is not clear. P6237 line 26 "in" instead of "into" P6238 beginning This is very hard to see without a proper chart. P6238 line 12 "... similar to that in the Southern

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Ocean." P6238 line 13-14 and paragraph: It is not possible to see this in the figures. At no spot the positions of the fronts are visible. There are many other places in the manuscripts where the same holds true. The authors should find a solution for this.

P6238 line 24 delete "extremely" P6238 line 24-27 The authors mention slight improvements. Did they find these themselves? Any results?

P6239 line 2 "... if it is also appropriate in marginal seas." P6239 line 14 "amounts" instead of "concentrations" P6239 line 15 I did not find any indication in the manuscript to what extent the algorithms for the 1990s and 2000s differed. Please provide more info, possibly in a different section of the manuscript.

P6239 line 19-29 This part is not well written and should be rephrased. The sentence starting with "Giving" is flawed. It is not clear where the words "this" refer to. Variability of what? And what's more, I think this is typically a text for the Conclusions section.

P6240 line 8 Again GLODAP is a data effort which delivered a data product, whereas CLIVAR is a measurements project delivering new oceanic data. Instead of CLIVAR, CARINA and PACIFICA can be used. If the emphasis is on the data collection, WOCE should be used instead of GLODAP – however, I think the authors use the adjusted GLODAP data, right?

P6240 line 12 delete comma after ASH P6240 line 17 Larger errors in what? P6240 line 24 Add semicolon after CLIVAR

Table 3 Please give the formula for referral. Explain RSE. Write: dissolved O₂, respectively

Figure 1 The figure caption needs more info on the cruise (where is it?), which data (measured or adjusted?). I cannot find the A,B,C,D,E , but it is also possible to leave those out as the variables can be read in the panels.

Figure 2 I am not convinced that the minimum in chi square for DIC is at 27.5 From the figure I read 27.4.

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Figure 3 Measured alkalinity and DIC for all data points, I guess? Then please add this info. Also add at the end: (see text for explanation)

Figure 4 "using" is used twice in one sentence. Please rephrase. As Fronts are mentioned in the text (e.g., Polar Front), these should also be indicated in the figure.

Figure 5 "using" is used twice again in one sentence. Are aragonite and calcite carbonate parameters (as written here)?

Figure 6 A,B,C,D appear somewhat small.

Figure 7 A,B,C,D appear somewhat small. The figures are too small and do not show sufficient detail for a detailed discussion like in the manuscript text.

Interactive comment on Biogeosciences Discuss., 10, 6225, 2013.

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