

Interactive comment on “Measurements of total alkalinity and inorganic dissolved carbon in the Atlantic Ocean and adjacent Southern Ocean between 2008 and 2010” by U. Schuster et al.

U. Schuster et al.

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We thank the reviewer for the careful assessment of our manuscript and their comments that improve it. Below we give the reviewer’s comments after “Comment”, and our response below each one after “Response”.

Comment: This is an important contribution to marine carbon cycle science. However, it is also a shame that Schuster et al., provide no information on the ancillary data required to interpret the carbon data that they report on, i.e. salinity, temperature, nutrients and oxygen. I think that whenever measured, information on these data, methods

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Discussion Paper



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Comment

and QC, should be included in reports such as this as they are vital for interpreting the carbon data. Ideally these data should be subjected to the same level of QC as the carbon parameters. The analyses performed in CARINA for instance, revealed huge issues with nutrient data, so even if these are frequently considered as routine measurements, they may have significant errors.

Response: The reviewer is correct that the manuscript concentrates on the DIC and TA measurements done during the cruises, as this is the emphasis of the paper. It is also correct that the ancillary data are required for interpreting DIC and TA. A comprehensive paper on temperature, salinity, nutrients, and oxygen would necessitate the effort of the data generators of the parameters during the cruises, and is, unfortunately, beyond this current paper presented here. We have, however, added citations at the end of section 2, of the standard operating procedures developed during the era of the World Ocean Circulation Experiment (WOCE) that are now maintained by GO-SHIP; these procedures were followed for physical and biological measurements during hydrographic sections. We added at the end of section 2: “Details of the measurements of temperature, salinity, and nutrients are not included in this paper as its emphasis is on DIC and TA, but sampling, analysis, and quality control procedures have followed recommended standard operating procedures developed during the era of the World Ocean Circulation Experiment (WOCE) in the 1990s, which are now maintained by GO-SHIP (Hood et al., 2010). WOCE and GO_SHIP SOPs are for salinity in (Stalcup, 1991) and (Kawano, 2010), for nutrients in (Gordon et al., 1993) and (Hydes et al., 2010), and for dissolved oxygen in (Culbertson, 1991) and (Langdon, 2010). Detail for the cruises covered in this paper are given in (Bacon, 2010) for DI332, (King and Hamersley, 2012) for DI346, (King and Hamersley, 2010) for JC032, and (McDonagh and Hamersley, 2009) for JC031.”

Comment: P624 line 1-2, add citation for this statement

Response: We added the citation of Sabine et al. (2004) and modified the sentence to be more precise.

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Comment: P624 line 3-4, for added impact, please specify how much higher the atmospheric CO₂ concentration would have been.

Response: The CO₂ in the atmosphere would be approximately 80 ppm higher (depending on variability of CO₂ sources/sinks and time periods considered) had the ocean not taken up atmospheric CO₂; this has been added to the text.

Comment: P624 line 19-21, please add citation for this statement.

Response: We have re-phrased the two sentences into one and added citations for both the MOC and AMOC: (Pérez et al., 2013; Broecker and Peng, 1992; Watson et al., 1995).

Comment: p630 line 19, please delete "value"

Response: "value" deleted.

Comment: p630-631, 1st level QC. At line 17, the authors state that during the 1st level QC, the data were checked for obvious outliers, however in Section 4.1 not further detail is provided on this routine. Please provide some more information on how outliers in the dataset were detected (for instance through property-property plots) and how they were dealt with, i.e. flagging or exclusion.

Response: Details of how 1st level QC were done are included now in Section 4.1: "WOCE quality flags (Joyce and Corry, 1994) were then assigned to each sample, initially flag 2 for all measurements. All DIC and TA were then checked for obvious outliers, identified by unusually high differences between duplicates, unusually high differences to neighbouring niskins after optimum interpolation, unusually long TA or DIC titration times, non-smooth titration curves, unusually high residuals in calculated TA. All such outliers were then flagged 4 when identified as a bad measurement, and flagged 3 when questionable. Finally, when duplicates' flags were 2 or 3, the mean DIC or TA of the two was reported with the highest WOCE flag of the duplicates for DI346, JC032, and JC031. The precision of DIC and TA measurements, defined as

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the standard deviation of in-bottle duplicate measurements ((Dickson et al., 2007), SOP 23) is given in Table 3.”

Comment: p631, lines 3-6. Please add information on typical magnitude of the CRM offsets that were used to correct the data. Please also add information on the variability of these offsets. I think that this could be suitably addressed by adding one figure for each cruise, that shows all CRM DIC and AT offsets as a function of time.

Response: We have prepared figures for DIC and TA for each instrument used on each cruise. These figures can be included in section 4.1, but as there are 14 figures in total, these could be included in an appendix to the paper.

Comment: Table 1. The expocode for James Cook, is not 74OH (with the letter "O") as given in this table, but 740H (i.e. 74"zero"H), see also <http://www.nodc.noaa.gov/General/NODCArchive/platformlist.txt>

Response: we thank the reviewer for the careful checking and highlighting the error in the EXPO code for RRS James Cook, it has been corrected.

Comment: Further, for cruise DI332, "a minimum of three duplicate depths" were sampled at each sampling station. If the authors drew and analysed samples from each of the duplicate niskins at these depths, please present the mean standard deviation of these measurements, this will provide excellent information on the precision of the analyses, including errors that may have arisen during the sampling procedure.

Response: As all samples during DI332 were drawn into 250 ml bottles, from which only one combined measurement of DIC and TA was possible, all duplicates of DI332 were same-depth duplicates, in contrast to the other cruises were 500 ml samples allowed for in-bottle duplicates. We have added in the text the information of same-depth duplicates during DI332, and (now) Table 3.

Comment: Finally, I am a bit confused by the statement "1st level quality controlled: :were submitted...at the end of the cruise to CLIVAR and Carbon Hydrographic Data

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office (CCHDO), and 2nd level quality controlled data (...) have been included in the GLODAP 2 effort via CDIAC." that appears in the sections on DI346 and JC032. The ramifications of this is that the data at CCHDO have only been subject of primary QC, where as the data at CDIAC has also been subjected to 2nd QC, so that, in principle, different versions of these data resides as these data centres. If this is the case, it is unfortunate, if I have misunderstood, please clarify.

Response: We thank the reviewer for picking up this confusion. Version of data at different data centres are the same: at the end of DI346 and JC032, 1st level controlled data were submitted to CCHDO as "end-of-cruise", then final, 2nd level controlled data were resubmitted to CCHDO, and submitted to CDIAC for inclusion in GLODAP 2. This has now been corrected in the manuscript.

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