Biogeosciences Discuss., 10, C6784–C6792, 2013
www.biogeosciences-discuss.net/10/C6784/2013/
© Author(s) 2013. This work is distributed under
the Creative Commons Attribute 3.0 License.

Biogeosciences
Discussions
Open Access

Interactive comment on "The seasonal cycle of $\delta^{13}C_{DIC}$ in the North Atlantic Subpolar Gyre" *by* V. Racapé et al.

V. Racapé et al.

vrlod@locean-ipsl.upmc.fr

Received and published: 22 November 2013

Anonymous Referee #1 Received and published: 2 October 2013

REFEREE: Specific comments Temporal distribution of data The phrase describing the temporal distribution of your data, 'between 2005 and 2012,' which appears in the Abstract and throughout the paper, is misleading. It implies that there is an at least semi-continuous set of data during this period, when in fact there is only data at the start and at the end of it. Initially, I would have been happy with changing this to something along the lines of 'in 2005-6 and 2010-2,' and I wouldn't have considered this too serious an issue. However, delving into the detail of the Results and discussion section we find (I am 95% sure, because the wording is not completely clear – p. 14522, lines 25-6) that in fact the main numerical result of the paper – the amplitude

of the _13CDIC seasonal cycle – is derived only from the 2005-6 data. It may well have been shown that it agrees with some of the other data set (only some of it – see later paragraph re. data chosen for exclusion) from 2010-2, but the implication in the Abstract that the value given for the seasonal cycle amplitude is derived from data from "between 2005 and 2012" is unacceptable.

RESPONSE: We tried to characterize the two periods but as you pointed out, the formulation is too general in the abstract (p#15516, l2) and in the introduction (p#14417, l28). In this context, we have replaced "between 2005 and 2012" by "in 2005-06 and 2010-12" as you suggested. To clarify it further, we report separately the seasonal amplitude for 2005-06 period (0.77$\pm$0.07‰ and for 2010-12 period (at least 0.69$\pm$0.10‰ in the abstract. This is further explained in section 3.3. Mean δ13CDIC seasonal amplitude of 2010-2012 was estimated between August 2010 and March 2011 and between March 2012 and June 2012. The August 2010 δ13CDIC values were considerd as the minimum for the summer season and we assume that in the month of June the seasonal maximum has not yet been reached, hence we have indicated "at least".

REFEREE: Coccolithophore bloom hypothesis To explain the 'anomalous' values of _13CDIC measured in August 2010, a coccolithophore bloom is invoked. There are many problems with this idea, and it certainly should not be in the presented in the Abstract. Firstly, I am not convinced that there even is enough data to be sure what is 'normal' and therefore identify something as an anomaly. That aside, let us assume that this data is indeed anomalous. It is admitted that there is no evidence of coccolithophores because of cloudy conditions occluding satellite imagery ('it is difficult to confirm this hypothesis' should be stronger: 'it is impossible: : :'). It is stated that the shallow MLD and high temperature would promote a coccolithophore bloom in August and Raitsos et al. (2006) is referenced to support this idea. In fact, that paper does not really support this hypothesis, for several reasons: (1) the timing is not right – the anomaly is in August, while Raitsos et al. say 'coccolithophores in the subpolar North Atlantic occur at their highest abundance during late spring/early summer and peak in

June'; (2) as the timing is not right, a different explanation is needed for the initiation of the bloom – Raitsos et al. say 'it must be noted that whenever high SST anomalies occur it does not mean that a bloom will be formed, but when it co-occurs with the timing of coccolithophores it will probably benefit the bloom'; and (3) it was too cloudy for any satellite imagery, which implies that there was not high solar radiation at the sea surface, but Raitsos et al. say 'the combined effect of high solar radiation, shallow MLD, and increased SST were highly correlated with coccolithophore abundance'. Perhaps it is meant that there was a big bloom earlier in the summer and the low _13CDIC has persisted, but that is not what is stated in this paper. Next, even accepting for the sake of argument that there was a coccolithophore bloom, no evidence is provided that it would actually reduce DIC without affecting _13CDIC. They may well produce calcium carbonate shells, which do not fractionate carbon much, but they also produce organic matter, which presumably does. Finally, there are other, more parsimonious explanations for the 'anomaly' which are not considered. For example: is there also a low salinity anomaly – would an increase in freshwater input reduce DIC without affecting _13CDIC? Or: relatively, there was a very deep winter MLD at the start of 2009 – could this have lowered _13CDIC at the surface, and persisted through to August 2010? _13CDIC should re-equilibrate with the atmosphere much more slowly than DIC after such an event. In conclusion, the coccolithophore bloom hypothesis is probably worth including, but (1) with more caveats given, (2) not as the only option, and (3) not in the Abstract.

RESPONSE: In our opinion, values of δ13CDIC and DIC measured in Aug. 2010 are really far away of the data distribution observed at other times, and these for the two periods (2005-06 and 2011-2012). To clarify this statement and to answer the question on "Data exclusion", we have estimated three DIC-δ13CDIC relationships observed over these two periods. (1) From July 2005 to June 2006, δ13CDIC=-0.108*[DIC]+24.10 (r^2=0.94), this is not significantly different from Eq.(4) which was derived including 3 values (of 4 sampled) for June 2006. (2) From Aug. 2010 to March 2011, δ13CDIC=-0.0074*[DIC]+16.6 (r^2=0.94), mentioned discreetly p#14524, l23 (3) From March 2011

to Sept. 2012, δ13CDIC=-0.0108*[DIC]+23.81 (r^2=0.95), which is Eq (5) in the first version of our manuscript. The estimated relationships exclude only data from Nov. 2006 that do not line up with any of these linear regressions.

Based on a student t-test, there are no significant differences between the slope of Eq. (1) and (3). These 2 slopes are close to the theoretical values (-0.011‰(μmol/kg), p#14522, l12) if the organic carbon production and respiration were the only processes affecting DIC and δ13CDIC distributions. Conversely, the slope of Eq (2) is significantly different from the two others and suggests that additional mechanisms also contributed to their distribution, thus changing the relationship.

We did not intend to mention the coccolithopore bloom as the only hypothesis to explain the Aug. 2010 "anomaly" (as we mentioned discreetly p#14524, l24). Some environmental conditions such as a shallow MLD and high SST observed early in the summer were favorable for a coccolithophore bloom. As δ13CDIC and DIC values observed in Aug. 2010 reflect on processes that occurred prior to the sampling date, the specific values of the two parameters in August 2010 could result from a coccolithophore bloom started in June. High biological activity dominated by coccolithophores would induce by their organic pump a winter to summer increase in δ13CDICand decrease in DIC according to a variation of around -0.011‰(μmol/kg) and by their carbonate pump, an additional decrease in DIC without affecting δ13CDIC and thus a change in the seasonal relationship between the two parameters as we observe between Aug. 2010 and March 2011. Estimate of the $\Delta\delta$13Cphy between Aug. 2010 and Dec. 2010 (Table 1) suggests that other physical mechanisms contributed to change δ13CDIC from summer to winter. As you mentioned, no hypothesis about the physical processes contribution was presented in section 3.3. These have been considered in the revised manuscript. Salinity temporal distribution has been included on fig 2 (maybe we can also include it on fig 5) and indicates that there is no low salinity anomaly in Aug 2010 which could explain the low DIC concentration. As you mention, "there was a very deep winter MLD at the start of 2009 – could this have lowered _13CDIC at the surface, and

persisted through to August 2010". This is possible (and mentioned p#14522, l23 but not used after) and could explain the low δ13CDIC values observed in Aug. 2010 while we expected that they were higher due to the high biological activity observed, but if the organic pump is the major driving processes, we expected a winter to summer increase of δ13CDIC according the slope of -0.011‰(μmol/kg). The combination of this process could explain values observed in Aug. 2010. Coccolithophore bloom being common in the NASPG, it will be interresting to estimate the relationship between δ13CDIC and DIC in a coccolithophore bloom in order to validate this hypothesis and to better understand the carbon cyle evolution in this region.

All these arguments have been included and detailed in section 3.3. The 3 linear regressions presented at the beginning of this response are included in section 3.2 which enables us to reorganize this section using the anomaly term as little as possible. The abstract has also been revised and the coccolithophore bloom hypothesis removed.

REFEREE: Data selected for exclusion This leads on to the data selected for exclusion. The 'anomaly' from August 2010 has been discussed at length. As I mentioned, I am not convinced there is enough data to establish 'normal' conditions, and justify its exclusion. It is claimed the data from June 2006 were dropped because there are only 4 measurements; how is this a valid criteria for exclusion? From Figure 3(a) it looks like these data have actually been ignored for convenience, because one of them falls in the range of the August 2010 'anomaly'.

RESPONSE: see previous response

REFEREE: The calculated amplitude of seasonal _13CDIC variation should either (1) include all of the data and have a larger error (there is no error estimate reported at all in the Abstract alongside the amplitude value, which needs fixing); or (2) be reported as separate values for different years with different conditions. Reporting a single value in the Abstract implies that all of the data agrees with it.

RESPONSE: In the end, we have chosen to report and discuss the seasonal δ13CDIC

amplitude values for each period as was already explained in the response to "temporal distribution of data".

REFEREE: Technical corrections

- Abstract, line 8: Would be useful to state the polarity of 'strong linear relationship' here RESPONSE: All right, 'strong and negative linear relationship'

- p. 14517, lines 3-10: Might be clearer to put these numbers in a table? RESPONSE: I am not sure that it is necessary.

- Lines 13, 17 + 19: d-1 is an unclear unit. Please write out decade-1 (I assume) RESPONSE: This unit is written "/decade" in our .doc. This seems to be an editor decision. To remove this pb, we have converted in /yr

- Line 28: 'between 2005 and 2012' – see Specific comments RESPONSE: see specific response

- p. 14518, line 13: were => are RESPONSE: OK

- Lines 21-22: remove 'depending on season with high' (typo) RESPONSE: This is not in our .doc version send to BGD. May be an infomatic typo. we will be more attentive for the revised version.

- p. 14519, line 10: accuracy 'close to' _0.02 per mille? What was the actual value? RESPONSE: This is more accurate in this new version. The new sentence is "δ13CDIC values have a precision of $\pm$0.01‰ (Vangriesheim et al., 2009) and a reproducibility of $\pm$0.02‰ and DIC concentrations have an accuracy about $\pm$ 3 μmol kg-1"

- Line 25: 'around' -24 per mille – why 'around'? Did you not use precisely -24 in the calculation? RESPONSE: Yes, we have removed "around".

- p. 14520, line 3: to => with RESPONSE: ok

- Line 15: 'the DIC gradient : : : which increases northward' – the DIC increases

northward, the DIC gradient does not (in fact, the DIC gradient with latitude decreases northward according to Fig. 2(b)+(d)) RESPONSE: we have changed this sentence to "This is opposite to the DIC distribution (up to 100 μmol kg-1; Fig. 2 at the middle) which increases northward as observed previously by Corbière et al. (2007)".

- p. 14521, line 8: 'seems to be lower' – are they or aren't they lower? Why only seems to be? RESPONSE: Are lower! We have removed "seems to be"

- p. 14522, line 1: 'seem to be' – see previous comment RESPONSE: idem

- Lines 1-2: '[some data is] organized linearly above [other data]' – I know what you are trying to say but this statement is meaningless RESPONSE: this was replaced by "There is a linear relationship between the concentrations of δ13CDIC and DIC although a difference in the concentrations is observed between all data collected in 2005–2006 and those sampled between 2010 and 2012, with the exception of data from November 2006".

- p. 14523, lines 13-14: 'Minima are observed : : : whereas maxima are estimated' – 'observed' and 'estimated' are not synonymous – did you observe the minimum and estimate the maximum? Observe both? Estimate both? RESPONSE: The minima in winter are established when the rate of change in concentration is at its annual minimum. Hence it is reasonable to deduce that values from winter are indeed minima. We have no data from july in the dataset so the timing on the maxima is estimated. The sentence could be : Minima are observed in February-March whereas maxima are estimated in to be in August during the summer bloom (Antoine et al., 2005; Corbiere et al., 2007) since there is no data from July.

- p. 14524, lines 10-11: 'the NASPG experienced a significant warming (+2_C) during 2010.' This is ambiguous – did it get 2_C warmer during that year, or was the maximum temperature 2_C than normal, or the average temperature? RESPONSE: The average monthly temperatures are 2°C higher than normal. We have added anomalous in the sentence : "the NASPG experienced a significant anomalous warming (+2_C) during

2010

- p. 14526, line 4: soft tissu => soft tissue RESPONSE: OK

- p. 14528, line 28: Raitsos et al. (2006) reference is out of alphabetical order RESPONSE: ok

- Table 1, caption: 'over the period 2005-2012' – see Specific comments RESPONSE: OK

- It is not clear what you mean by ntot and n RESPONSE: we have removed ntot and keep n, the data number used to estimate the average values of each parameter.

- The units are out of column alignment RESPONSE: This is not in our .doc version sent to BGD. May be an infomatic typo. we will be more attentive for the revised version.

- Would be better to have an indication here of which data you chose to exclude RESPONSE: This is indicated in the Fig 3 where we estimate both linear regressions.

Figure 1, caption: 'over the period 2005-2012' – see Specific comments - Dashed lines indicate surface currents? - You mention specific lat/lon points for Reykjavik and Newfoundland in the text – would be good to see these marked on this map RESPONSE: OK

- Show 2005-6 and 2010-2 cruises in different colours? RESPONSE: This is not helpful because 2010-12 data overlap the 2006 data. Only data collected in 2005 move slightly but as Corbiere et al. 2007 mentioned, there "is no impact for the seasonal and interannual analysis presented in this study" [2005-2006].

- Use of an arrow to show data used in study is very imprecise and leaves ambiguity as to which data are used. Use a (shaded?) box? RESPONSE: we have replaced arrow by a box

Figure 2. As for Figure 1, arrows are imprecise, although less of a problem here (because data selection is perpendicular to the arrows) RESPONSE: Fig. 2 has been

revised considering your comments and those from the second referee. 1) We have replaced the arrow by a box to show the selected region. 2) We have changed the picture order to make them easier to comprehend (as DIC increase) 3) We have added a graph of salinity temporal variation to inform about a potential natural impact on DIC increase. As salinity was not measured in April 2006, we have a preference for this graph (salinity alone) instead of normalized DIC graph which has however been included in table 1 in order to have all available information.

Interactive comment on Biogeosciences Discuss., 10, 14515, 2013.