Biogeosciences Discuss., 6, C4373–C4378, 2010
www.biogeosciences-discuss.net/6/C4373/2010/

Biogeosciences Discussions

Interactive comment on "Contrasting effects of temperature and winter mixing on the seasonal and inter-annual variability of the carbonate system in the Northeast Atlantic Ocean" *by* C. Dumousseaud et al.

C. Dumousseaud et al.

eric@noc.soton.ac.uk

Received and published: 5 February 2010

Reply to anonymous referee #3:

We would like to thank the reviewer for his/her valuable comments which helped us to improve this manuscript. Our responses to the specific comments are listed below:

The manuscript is well written, straightforward and descriptive. However, the most important item is not addressed and the section about the inter-annual variability has a bad approach in my opinion. We disagree about the important item (see below) and have revised the section on inter-annual variability.

The authors have collected an impressive data set for CO2 and related parameters across the English Channel and Bay of Biscay spanning a time period of two complete years. These measurements show the seasonal pattern of the air-sea CO2 exchange that is related to net biological production, temperature, and physical processes.

Many of the things below are minor corrections to the text, but there are a few points that they should consider. Further, it seems to be not suitable for publication in the present form.

Specific comments: Attending to the seasonal distribution of the variables showed in the Figures, the interannual changes recorded from underway measurements seem to be due to influence of continental inputs that are more abundant during negative NAO scenario at these latitudes (Perez et al., 1995, 2000). The surface waters during the first winter were less saline than during the second winter. The abnormally low temperature and the intense nutrient concentration of these waters seem to show the presence of a surface layer of freshwater as well. Moreover a situation of thermal inversion as it could be sampled during this first year would produce the intense mixing layer from temperature criterion observed in the manuscript. Please, check this supposition. - This is an important point. However, we think that the changes in salinity observed (the average difference observed between the two winters for December and February is 0.1 $\pm$0.1) do not represent a statistically significant variation or a variation that is important enough to explain the observed differences in nitrate concentrations between the two years by the influence of continental inputs. It seems to us rather unlikely that altered river inputs would affect all parts of our transect including the deep Bay of Biscay far from any large river mouths (there are no large rivers entering the Bay of Biscay from northern Spain, and prevailing currents tend to sweep the river plumes entering from the Loire and Gironde in a northwesterly direction). The difference in winter mixing observed between the two years is most likely to be the principal source of variability.

BGD

6, C4373–C4378, 2010

Page 9706 line 14: ±4-6 μmol kg-1, it is a mistake. - The range cited in the text is the actual mean difference observed for the months where good agreement was observed between the fCO2 measurements from the Santa Maria and our DIC and TA measurements and does not include the corrected months. In the revised version of our manuscript we have included a few more months for comparison and the range of the difference between measured and calculated monthly DIC has been modified in that respect. The difference observed for the corrected months has been added in the revised manuscript.

Page 9706: It is not sufficiently clear as the correction of the DIC measurements were done. Please, describe with more detail. - This section has been modified and more details have been added regarding the correction.

Page 9707: There exist a number of formulations of piston velocity as a function of wind speed, and they often produce quite different air-sea fluxes. The authors should justify why they chose the formulations proposed by Nightingale et al. (2000) and Sweeney et al. (2007). - The equation of Nightingale et al. (2000) is based on an extensive data set of tracer release experiments over a wide range of locations and wind speed measurements (Schuster et al. 2009). The equation from Sweeney et al. (2007) was used for comparison. This has now been specified in the text. The equation of Wanninkhof (1992) was not used due to recent studies showing possible overestimation of air-sea fluxes using this scaling factor at higher wind speeds.

Page 9707: The authors chose the wind speed of the MET Office Gascogne Buoy. Nevertheless the most used choices are the products obtained from QuikSCAT sensor and NCEP/NCAR re-analysis model. Could you also compute the air-sea CO2 exchange using the wind speed obtained from QuikSCAT sensor or NCEP/NCAR model and describe the differences? - Thank you. We have now obtained the QuikSCAT wind speed data for each of the regions studied which has now been used for the calculations. The figure 7 and the discussion have been modified in that respect.

Page 9708: The temperature criterion ($\Delta T=0.5^{\circ}C$) yields estimations of mixing layer depth different that using density criterion. For this reason, I would like to know the seasonal distribution of MLD using density criterion. - The MLD has now been estimated using both the density and temperature criteria and the corresponding graph has been modified in that respect.

Page 9711 line 10-13: The estimation of the impact in TA related to the growth of coccolithophores showed a minor influence on the total TA changes. Could this estimation be sub-estimated due to an unsuccessful sampling strategy or the sedimentation of particulate inorganic carbon? - This is possible. However, the satellite images observed for the time of our study showed low bloom conditions in this area compared to previous years or other studies (confirmed by the coccolithophores abundances observed in this study). This calculation does not represent a key point in this manuscript, and this section has now been removed.

Page 9712 line 1-2: According to the sentence "The DIC concentrations showed an overall increase with latitude for all crossings", minimum value should be located in the Southern Bay of Biscay. - Thank you. This was due to similar values observed for this month in these two regions and the text has been modified in that respect.

Page 9714: The C:N ratio of 8.4 represents an approximation of the mean value of the seasonal production (Kortzinger et al., 2001) while 6.6 is a the classical C:N ratio that describe the new production or the ratio of particulate organic matter in the mixed layer. Please, clarify. - The DIC/Nitrate ratio has been used to estimate the surface waters seasonal drawdown and as a comparison with the observed nitrate and DIC seasonal drawdown. This section has now been clarified.

Page 9714: The sampling region is within subpolar latitudinal band. Therefore a dominant negative NAO phase correspond with positive SST anomalies and less vigorous winter mixing than normal whereas positive NAO scenario is expressed by negative SST anomalies and an intensification of mixing processes during winter. - We dis-

BGD

6, C4373–C4378, 2010

Interactive Comment

agree on that point as high (>0) NAO winter index are linked with positive temperature anomalies and shallower mixed layer depth, while low (<0) NAO index are linked to negative temperature anomalies and deeper mixed layer depth in our study region. This was shown by several studies such as Osborn 2006, Marshall et al. 2001 (e.g. Plate 1), and Hurrell and Deser 2009 (e.g. Figure 8), who previously showed a positive correlation between temperature anomalies and winter NAO index within our study region. The increase in storminess observed during dominant positive NAO index as explained by the reviewer is observed at higher latitudes in the vicinity of Iceland as seen in Hurrell and Deser (2009, Fig. 8 bottom panel) which shows the spatial pattern of the NAO mode from a EOF/PCA analysis of the winter mean sea level pressure. The Bay of Biscay is covered by contours of the opposite sign to the areas farther north – which means whatever goes on in the north in terms of storminess (e.g. more storms/winds during NOA+), the opposite happens farther south.

References: Osborn T.J. 2001. Recent variations in the winter North Atlantic Oscillation. Weather 61 (12).

Marshall J. et al. 2001. North Atlantic Climate variability: phenomena, impacts and mechanisms. Int. J. Climatol. 21, 1863-1898.

Hurrell J.W. and Deser C. 2009. North Atlantic climate variability: the role of the North Atlantic Oscillation. J. Mar. Sys. 78, 28-41.

Page 9714: The analysis of interannual changes from two consecutive years using the NAO index whose signal in the subpolar (subtropical waters as well) North Atlantic is delayed approximately three years (Edeng and June, 2001) is not properly focused. - The discussion part where the NAO index is mentioned present a possible explanation for the inter-annual differences observed between the two years. The difference in winter mixing is observed between the two years and is most likely the principal source of variability. However, as shown in several recent studies (Bates et al. 2001; Gruber et al. 2002), the variability of the carbonate system seems to be directly influenced by

BGD

6, C4373–C4378, 2010

the NAO.

Page 9716: I have estimated the winter oceanic pCO2 from the values of DIC, alkalinity, salinity and temperature that you showed in the Figures and I have not found similar values during the two winters. - Ok, this has been rephrased. The reviewer's estimates agree well with our calculations and the text has now been clarified.

Interactive comment on Biogeosciences Discuss., 6, 9701, 2009.