

Interactive comment on “Air-sea CO₂ fluxes in the Atlantic as measured during the FICARAM cruises” by X. A. Padin et al.

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Anonymous Referee #3 Received and published: 30 July 2009 General comments: The manuscript presents the air-sea CO₂ fluxes in the Atlantic Ocean along meridional cruise tracks during boreal autumn and springs seasons. It also identifies an empirical algorithm for modelling surface seawater CO₂ fugacity (fCO₂) from other parameters in order to analyse the forcing of the fCO₂ variability. The manuscript is well structured and represents a substantial scientific contribution notably because of a unique dataset. I recommend publication after the authors addressed the following comments.

Specific comments: The authors group their data into established biogeochemical oceanographic provinces and local (i.e. within province) latitudinal variations in surface seawater properties are presented/discussed in the manuscript (e.g. Fig. 2). However,
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the existence and influence of longitudinal gradients are not considered. Such gradients are especially relevant for the North Atlantic where cruise tracks vary substantially (Fig. 1 in the manuscript). This poses the question: do cruise track changes contribute to the interannual (i.e. inter-cruise) variations presented in section 3.3? We assume a longitudinal contribution almost null along the Atlantic Ocean. The meridional distribution of most of these variables as SSS and SST (World Ocean Atlas 2005) and $\Delta f\text{CO}_2$ and FCO₂ (Figure) estimated by Takahashi et al. (2009) at monthly and seasonal scale or SST and SSS mainly explain most of the spatial distribution of them.

Net flux of CO₂ in the Atlantic Ocean (Takahashi et al., 2009)

Data from two seasons (boreal spring and autumn) is analysed in the manuscript and authors refer to the observed spring-autumn differences as seasonal changes, seasonal shifts, and/or seasonal differences, seasonal amplitude etc. in several places of the manuscript. The above terms are also normally used to describe changes that take place over a complete annual cycle. To avoid ambiguity, authors need to be more specific about which seasons they are referring to. For instance, sentences like “Differently, almost negligible seasonal SST differences were observed in equatorial regions (NECC region; Table 2).” could be modified to “Differently, almost negligible spring autumn SST differences were observed in equatorial regions (NECC region; Table 2).” We agree with your comments and so, the manuscript was properly corrected.

Technical comments: The title should be changed for more accuracy by including “spring and autumn seasons”, For example: “Air-sea CO₂ fluxes in the Atlantic during boreal spring and autumn seasons”. We have accepted your suggestion

Page 5590, line 24: “released to the atmosphere only half of it (~ 9.1 PgC yr⁻¹ at present; Canadell et al., 2007.” should read” released to the atmosphere (9.1 PgC yr⁻¹ at present; Canadell et al., 2007) only half of it.” We have accepted your suggestion

Page 5591, line 22 at the end. Please give examples of databases. Page 5592, middle

of line 5, remove the word "at". We have accepted your suggestion

Page 5594, lines 15-19: The use of different SST and SSS sensors can introduce offsets, could this be the case for the present data? The equipment used in the project FICARAM was the same with the exception of thermometer installed into the ship's hull. So, the thermometer in the B/O Hespérides belongs to its data acquisition system while SST in B/O Las Palmas was measured with an own thermometer. In any case, every instrument were periodically calibrated

Page 5595, lines 8 – 10, the sentence starting with "Finally,..". If I understand it correct, fCO₂_atm was computed and compared with pCO₂_atm, and any values for which the difference was greater than 0.3% were not used. In nay case, please clarify how fCO₂atm was computed. Manuscript has been changed for clarity. The new version is: "The final xCO₂atm dataset was then converted to pCO₂atm (Eq. 1) considering the atmospheric pressure (p_{atm}) and the partial pressure of water vapour (p_{H₂O}), which was calculated from in situ SST readings (T_{is}; Cooper et al., 1998) (Eq. 2). The pCO₂atm values were then converted to fCO₂atm assuming a decrease of 0.3% from the pCO₂atm value (Weiss, 1974)."

Page 5598, lines 21 – 22: Authors state that "In general, Northern Hemisphere waters were warmer than Southern waters during the boreal autumn while the opposite prevailed during boreal springs (Fig. 2a, e)." This is not exactly true, except for NEC, NECC, SEC and STG provinces. The manuscript has been modified in order to include the correction.

Page 5602, line 9: the sentence beginning with "Alternatively,..". is difficult to understand. I guess the authors try to explain the cause of the super-saturation, but the word "alternatively" confuses since there is only one explanation put forward. Regardless, there is a need for a clarification. The manuscript has been modified to clarify the information.

Page 5602, lines 26-28: please provide reference for the seasonal shifts described for
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chl-a. The manuscript has been changed-

Page 5603, middle of line 11 "SAC" should read "SAS". The manuscript has been corrected.

Page 5603, middle of line 14 "SAS" should read "SAC". The manuscript has been corrected.

Page 5603, line 28, sentence starting with "All records: : ." I do not understand the last part of this sentence. The manuscript has been modified to clarify the information.

Page 5605, lines 9-11: I do not understand last part of the sentence "...so as to include them as well and complete the database." The manuscript has been profusely modified for clarity.

Page 5605, line 14-15: "The interannual variability of SST and fCO₂ indicate a warming and increasing CO₂ saturation of surface waters in the Eastern North Atlantic (Fig. 3a, b)." But these trends were not significant, correct? You are right. The manuscript has been changed. "The North Atlantic provinces (Figs. 3a, b and c) showed a slight year-to-year increase in SST in the spring and autumn seasons during the period of the FICARAM cruises (2000-2008)."

Page 5605, lines 17-21: It is difficult to know whether the authors suggest a relationship between NAO and warming and fCO₂ saturation, or if they are referring to an established relationship. Page 5605, line 27: "Fig. 4c" should read "Fig. 3c". The manuscript has been modified for clarity.

Page 5608, last line: I do not understand the sentence starting with "Furthermore, .." The manuscript has been modified for clarity.

Figure 1: please give the full names of the provinces in the legend. The names of the provinces has been included in the legend of the Fig. 1

Figure 2: the resolution is poor; the meaning of CPC does not appear anywhere in

the manuscript. I do not find it necessary to differentiate different cruises We have decide to separate the spring cruises from the autumn ones in order to analyze different behaviours of the Atlantic Ocean and clearly show the results and graphical description.

REFERENCES

Cooper, D. J., Watson, A. J., and Ling, R. D.: Variation of pCO₂ along a North Atlantic shipping route (U.K. to the Caribbean): A year of automated observations, *Mar. Chem.*, 72, 151–169, 1998.

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Weiss, R. F.: Carbon dioxide in water and seawater : the solubility of non-ideal gas, *Mar. Chem.*, 2, 203-215, 1974.

World Ocean Atlas 2005. National Oceanographic Data Center

Please also note the Supplement to this comment.

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