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Interactive comment on "Rapid increasing trend of CO_2 and ocean acidification in the surface water of the Ulleung Basin, East/Japan Sea inferred from the observations from 1995 to 2004" *by* J.-Y. Kim et al.

Anonymous Referee #2

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General comments: The manuscript presented twelve mean pCO2 data from field measurements (four been published before, eight present in this study) between 1995 and 2004. It investigated the CO2 increase and ocean acidification in the surface waters of the Ulleung Basin (UB) of the East/Japan Sea. The author estimated rates of increase of fCO2 were 3.36 μatm yr-1 for the surface ocean and then the ocean acidification trend estimated to be 0.04 pH units decade-1. Both estimated rates are double-times faster than the global mean. The estimations, however, seem to be questioned since they may have large uncertainties/errors involved. The reasons are listed as below: (1)

The areal mean of the cruise in terms of data accuracy and representativeness may be, for instance, problematic listed in Table 1; (2) That caused the authors with wrong estimations of trend rates and then overestimated only based on the limited periodic survey instead of decadal time-series measurements; (3) They made the big mistakes through the data making from one dataset to generate the one another data. The more data generated from one dataset through statistical method resulted in the final results may not be true. Overall speaking, they over-estimated by the wrong estimation.

Specific comments:

1. P9592 in Table 1: data accuracy and representativeness?

Is it representative for the cruise fCO2 mean? The authors did not discuss how they averaged. Since the spatial coverage of the cruise track was not all the same (Fig. 1), it may cause the weighted-mean or arithmetic mean biased. Further, the data in Table 1 for ΔfCO2 are somewhat doubtful. Please see the following table we made in the column of C-D in red. The ΔfCO2 data provided by authors are different from those we calculated from the difference between fCO2sea and fCO2air in A and B column, respectively. The authors shall explain why caused such differences.

Table 1

2. P9596 in Fig. 2:

The annual rates of fCO2 in seawater ca. 3.36 μatm yr-1 may not be right since the limited sampling in the marginal seas where exhibit large seasonal fluctuations in terms of complex currents and biogeochemical variability and inadequate spatial survey areas where are not the same for each cruises were involved. Therefore, the end results shall be wrong once the increasing rate was not correct.

3. P9579 & 9580: Reliability of time-series algorithms of fCO2sea ?

The time-series equation proposed by authors was initiated on a basis of two assumptions: 1. Decadal trend was constant; 2. Seasonal variability constant. Assumption 1 seems to be somewhat acceptable, but annual changes shall be greatly fluctuated in an offshore near coastal area of marginal sea. So, regarding the assumption of constant interannual variability we hold great suspicions. Anyway, authors didn't examine if the assumptions were proper or not before further algorithms establishment.

The establishment of time-series algorithm for computing fCO2 was based on (1): fCO21995 = fCO2in-situ - ra $\times$ (Year - 1995). where ra is 3.36 μatm yr-1, the slope of the regression line of fCO2 against year as shown in Fig. 2. Obviously, it is quite inadequacy of data sampling to have a representative trend, being further used to determine the ocean acidification rate. Consequently, the results showed ocean acidification rate in the East/Japan Sea was 2 times higher than the global mean according to the increasing rate of 3.36 μatm yr-1. It may be, however, overestimated on a basis of a wrong trend rate.

So, if we amend the rate, ra, to the increasing rate of atmospheric fCO2, 1.9 μatm yr-1, equation (2) could be solved in the text:

fCO21995 (t) = C0 + C1 sin(2πt) + C2 cos(2πt) + C3 sin(4πt) + C4 cos(4πt) C0= 333.46, C1= -38.02, C2= 18.16, C3= 5.96, C4= 23.33 (R2=0.85) where the R2 is even better than that for seawater (R2=0.82) observed at the ra = 3.36 μatm yr-1.

We can then trace back the in-situ fCO2 as fCO2 * by use of the equation (3): fCO2 * = fCO21995 (t) + ra $\times$ (Year - 1995). The outcome correlated well with the observed data which correlation coefficient is slightly higher than that at the ratio of 3.36. So, ra proposed in the text could be further refined/ constrained.

Fig. 1

In further analysis, assuming observed fCO2 data are representative, we can solve the optimal solution for ra in combination of equations (2) and (3)

fCO2* = C0 + C1 sin(2πt) + C2 cos(2πt) + C3 sin(4πt) + C4 cos(4πt) + ra (Year - 1995)

Therefore, we solve the five constant coefficients and ra, when the observed fCO2 data

present in the text brought into the above formula:

C0= 351.10, C1= -42.42, C2= 20.49, C3= -7.98, C4= 28.32, ra=-1.17 (R2=0.88)

The results showed an annual rate is negative, i.e., a decreasing trend. It indicated that there were problems of insufficient sampling in this study and difficulties of providing enough evidences to assure their assumptions and verify final results.

4.P9580: Is it true the statement that the flux had been decreased about 28 % during the last decade according to comparison results of the data obtained in 1995 with that in 2004? Why were the annual integrated CO2 fluxes estimated by Choi et al. (2012) and Oh et al. (1999) much larger than your results? Whose values are right? What causes the discrepancies?

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/10/C3986/2013/bgd-10-C3986-2013-supplement.pdf

Interactive comment on Biogeosciences Discuss., 10, 9573, 2013.

Figure 1

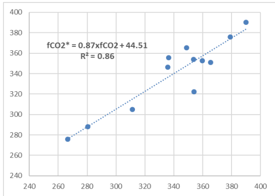

Fig. 1. Correlation between the fCO2 and estimated fCO2 at ra 1.9