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Interactive comment on “Air–water fluxes and sources of carbon dioxide in the Delaware Estuary: spatial and seasonal variability” by A. Joesoef et al.

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Summary

This manuscript presents a nice dataset from the Delaware Estuary and its largest contributing river. The Delaware Estuary is a relatively major East Coast system, and as such this work represents another piece added to complete the overall puzzle picture of estuary CO₂ dynamics along the U.S. East Coast, and to a certain extent on a more global basis. The sampling and analytic methods employed by the authors are well-documented and well suited to this system. The authors employ data analysis strategies previously used elsewhere by other authors, including myself, which is a

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reasonable approach. I do have some serious concerns about the presentation of the data, as well as some of the assumptions underlying the analysis, which are discussed in detail below. I think the work underlying this manuscript is well-founded, but the analysis and manuscript could do with some rethinking and a major revision.

Major Comments

-My greatest criticism of the manuscript is in the presentation of the data; specifically, the lack of information about variability. The most glaring example of this is Table 1. The authors present area-averaged pCO₂ and CO₂ flux estimates from five subsections of the estuary, but present no information about the range of these data, the standard deviation, or the median. These statistics seem vital to include in order to develop a total picture of estuary conditions. This is particularly important in light of the data presented in Figure 5, panel I. Most of the estuary transects follow a general north-south route, presumably following the main channel of the estuary. However, in December 2014 the authors made the wise decision to add some east-west transects as well, which show considerable variability. This makes intuitive sense, as the map of the Delaware Estuary (Figure 1) seems to show a number of smaller contributing rivers flowing into the bay from the east and west. Presumably if ranges and/or standard deviations were included in Table 1, the results would show much more variability during the December 2014 cruise than other cruises which only followed the north-south line. I suspect that this system is more complex than the presented data indicate, which is interesting! The authors acknowledge this "lack of cross-bay transects" in their Concluding Remarks, but this is a limitation that should be discussed much earlier and much more thoroughly. Some of the pCO₂ variability may be distinguishable in Figure 7, but this figure is so small, and the error bars so light, that I can't make much sense out of it. The authors even specifically mention that standard deviations of atmospheric pCO₂ and CO₂ flux were calculated (P10907L2-5), but I do not see these standard deviations presented anywhere. This overall lack of variability discussion really limits the discussion of the data, as well as the relevancy of the results.

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-The use of interpolation is somewhat unclear in this manuscript, and sometimes may not be appropriate. Specifically, on P10908L15-17 the authors state: "Temperature-normalized pCO₂ values during months with no surveys were estimated by linearly regressing data from adjacent months with sample measurements." However, Figure 7 does not show this. There were no cruises in January or February, but the plots in Figure 7 clearly show a non-linear patterns between December and March, when the plot should have shown a straight line according to the above description. How is this possible? There were also no cruises in April or May, but the same conflicting pattern is shown in Figure 7. I am also confused about the '0.01x0.01' latitude by longitude grid (P10906L16, P10904L15-16) employed in the analysis. Does this grid cover the entire Delaware Estuary, including those areas not occupied by the ship? If so, it seems unwise to extrapolate air-water CO₂ fluxes from the center of the estuary out to the eastern and western fringes where no data were taken and conditions may be quite different, and the east-west variability is essentially unknown. It seems much more reasonable to calculate overall pCO₂ levels and CO₂ fluxes (with accompanying variability statistics) for each of the five estuary subareas, instead of trying to interpolate the north-south transect data over the entire estuary. But perhaps I misunderstood the manuscript and the grid only covered those areas occupied by the ship.

-I understand the motivation to arrange the survey data in a non-sequential fashion, as in Figures 3-5 and Table 1, in order to try to depict a seasonal progression of pCO₂ and CO₂ flux. However, this arrangement may be pretty confusing at first glance, and may imply some variability that is not actually present; see for example panels 5D-F. This is particularly true in Figure 3, when it is very difficult to tell which bars are from which years. I also do not trust the results discussed in Section 3.5- how are seasonal distributions produced when there were no surveys in five of twelve months of the year?

Minor Comments

-OVERALL- please define the seasons, specifically which months or transects are included in which season when discussing the data.

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-OVERALL- Why partition the information in Appendices A and B? I can understand this strategy with some journals, but space is no object in Biogeosciences!

-OVERALL- This manuscript is in need of a thorough proofread. Examples include:
-Calculation of flux at pixel i , F_i , is shown in Equation 1, not Equation 5 as indicated in the text. -P10908L5: pCO_2 was presumably normalized to the annual mean temperature, and temperature was not normalized to the annual mean temperature as indicated -P10911L1: "The Delaware River discharged was..." -P10912L24: "atmosphere positive during all..." -P10917L13: "during the spring season..." -P10918L24: "to the rapidly flushing..."

-P10900L6: change to "the smaller upper tidal river..."

- P10900L7: change to "the much larger bay was a weak..."

-INTRODUCTION: some explanation of the delineation between small and large estuaries may be useful. The Introduction seems to be making the case for the importance of this work as contributing another estuary to global estimates of CO_2 flux, but some statements regarding why this is an important endeavor would strengthen this section. The Introduction also seems to argue that East Coast estuaries are under-studied, which may be true in absolute terms, but the East Coast is perhaps the most-studied region for estuary CO_2 dynamics in the world, excepting perhaps Europe!

-P10902L10-13: are there any estimates of how far up the Delaware River the tidal prism extends?

-P10902L16-18: this dynamic interaction can be a common feature in smaller estuary systems as well, depending on river flow and geomorphology

-METHODS: how deep was the seawater intake on the ship?

-METHODS- some description of the equilibration method used by the AS-P2 is needed

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-P10903L16- The LI-7000 is not a spectrometer

-P10904L3- Does filtration affect DIC?

-A nice examination of estuary air-water fluxes can be found in Ho et al. 2011: On factors controlling airwater gas exchange in a large tidal river. Estuaries and Coasts 34:1103–1116.

-P10906L5-9: Can you show the NOAA buoy locations on the map in Figure 1?

-P10908L5: Give the mean annual temperature (12.7°C) here.

-P10908L11: Change 'as a result of' to "to be the result of"

-P10908L12-13: "pCO₂ data obtained during each cruise was rarely stationary..." What does this mean?

-P10910L7-8: How were in situ DIC and TA measurements coupled? In CO₂SYS or some other program? Which carbonate K values were used? Much more description is needed here.

-With measurements of TA, DIC, and pCO₂, presumably pCO₂ was calculated from TA and DIC. How do these derived pCO₂ levels compare to observed pCO₂?

-P10910L3: This is the first mention of the Schuylkill river, which is not shown on the map. Were some river sites samples which are not discussed?

-P10910L8: awkward: "The CO₂ production or its contribution. . ."

-P10910L21-24: These water temperatures are just for the Delaware River, right? Show the USGS gage used for these measurements on the map.

-P10912L20-21: Why did pCO₂ go up in December 2014? It looks like low-salinity waters from the Delaware River stretch further south than usual, and flow in Figure 3 seems pretty high. Did a storm precede the survey that month?

-P10913L25: Give the magnitude of the contribution, even if it is minor.

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-P10915L13: How is the removal of CO₂ attributed to biology here? No evidence of biological activity is presented. Were oxygen data taken as well? O₂ data are mentioned later (P10916L18), but never presented.

-P10915L22-23: Again, what is the evidence supporting biological addition of CO₂?

-P10916L11-14: I don't understand what these percentages represent, or how they were calculated. This section could use some work to make the terms discussed more clear.

-P10917L23: Strong Co₂ sources to the atmosphere, or the Delaware Estuary?

-P10918L25: relatively weak compared to what? Put this number in some context. The following paragraph discusses relative CO₂ sources in some other estuaries, but gives no actual numbers.

-P10918L4-5: "to overall CO₂ fluxes". Are these fluxes for the entire estuary, or just these smaller sub-sections?

-P10918L26-29: This section is awkwardly written.

-P10919L3-5: No evidence is shown or discussed regarding estuary productivity in the Delaware Estuary or any other estuary.

-P10919L17-19: What does this sentence mean? Where is the evidence for this?

-P10919L17-25: This last paragraph seems ill-conceived. Are there historical data in the Delaware Estuary? If so, why were they not mentioned in the Introduction? If not, how are the past conditions known?

-FIGURE 7- The error bars on this plot are unreadable. In general, this plot is too small.

-FIGURE 8- Is a linear fit in the top panel really appropriate for five data points? Also, the different x-axis and y-axis scales should be clearly noted, or the panels should be depicted on the same scales. It might be interesting to plot the data from both panels

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in one plot- how would the Urban River points line up with those from the Turbidity Maximum Zone?

-FIGURE 9- This figure is totally unreadable- the colors of the bars are indistinguishable from one another. The different y-axis scales need to be noted. Also, are some data omitted from this figure? Table 1 shows data from June 2013 and December 2014, but those months have no results in Figure 9.

Interactive comment on Biogeosciences Discuss., 12, 10899, 2015.

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