

We thank referee Melissa Ward and the anonymous referee for their feedback throughout the review process that has resulted in a substantially improved manuscript.

Referee #1: Melissa Ward, maward@ucdavis.edu

Intro:

I will defer to the authors choice on this, but the intro as is may benefit from some brief additional explanation or clarification about the intertwined nature of the two key aspects of the study, 1- the carbonate chemistry variability, and 2- the air-sea fluxes of the estuary. As written, the air-sea fluxes feel like a somewhat of an afterthought. It might benefit authors to add some point to reiterate that they are interested characterizing carbonate chemistry to for two related reasons. To me, these seem like 1) to better understand the variation in seawater pH to provide context for ocean/estuarine acidification and its impacts and 2) to better understand the variation in seawater pCO₂ to improve estimates of air-sea fluxes (both of which are under characterized, particularly in their region). This slight distinction might set readers up well for the rest of the paper, but nonetheless, I believe it could be sufficient as is as well.

Response:

We added one sentence at the end of the introduction to make this intent clearer: “The characterization of carbonate chemistry and consideration of regional drivers can provide context to acidification and its impacts and improved estimates of air-sea CO₂ fluxes”.

Methods:

I appreciate the changes made to this section; it looks great.

Lines 132-134 the authors write “sampling was conducted every two weeks during summer and monthly during winter”, but it is unclear to me at what frequency. The supplemental material notes that for sensor calibration purposes, this was done via replicate samples by these sensors, but some clarity on how this was done for the air-sea flux calculations would be nice in the main paper. E.g., “These discrete samples were collected by taking 1 discrete surface sample within the site every two weeks”. These details seem pertinent to have in text because you go on to calculate air-sea fluxes from these samples, so knowing the exact details is important to inform interpretation of the spatial and temporal resolution of these fluxes.

Response: Sampling frequency has been clarified. It now reads “A single, discrete, surface water sample was collected every two weeks during the summer months and monthly during the winter months from a small vessel at a station near (<20 m from) the sensor deployment.”

Lines 229-230, 235 (the equations): change font to be consistent with font in the paper text and with equation 1.

Response: The equation font has been changed to match the text.

Results:

This section has been greatly improved since the last version and is far more streamlined with the material moved to the supplement. There are a number of smaller improvements that could be made described below.

Figure 4 – only one of these plots has an x-axis labeled “season”. Formatting issues with panel letter labels (c hard to find in the y-axis label). I might move the panel labels onto the figure.

Response: The misplaced “season” label has been removed, and figure layout has been changed to make sure that all plot labels are easily visible.

Figure 5- the x-axis label of “DATE” should be removed, as it is redundant. The y-axis labels also could be cleaned up removing the (Day-Night) label since this is redundant on each figure as well. I might suggest simply adding this to the figure caption but will defer to author/editor preference. It might also be nice to add the year (Jan-Jun) that this was conducted in the figure caption for clarity.

Response: The y-axes have been simplified (the daytime versus nighttime difference is now only described in the caption). The figure layout has been changed to make sure that all plot labels are easily visible. The figure caption has been altered to include the date range for these continuous data.

Figure 6 – similarly, adding the year to the top panel in the figure description might help for clarity to remind readers where this timeseries fits within the bottom two panels

Response: The figure caption has been altered to clarify the range of time for continuous versus discrete data. Plot labels have also been added to be more consistent with other figures.

Discussion

In general, a great discussion, although very long (almost 10 pages). I would recommend trimming where possible but agree with the authors’ overarching thoughts. I would also recommend sub-sub sections to break up the text if possible, given its overall length. For example:

4. Discussion

4.2 Factors controlling temporal variation in carbonate system parameters

4.2.1 Temperature

4.2.2 Biological controls

4.2.3 Tidal controls

4.2.4 Salinity

Etc

Etc

This would be very helpful I think to keep readers from getting lost in the block of text, and allow those interested in particular aspects of the work to more quickly zero in on sections of interest.

Response: We broke up section 4.2 into four subsections, similar to these suggestions.

A few additional specific recommendations below:

Lines 516-523: See my point above about methods. I feel that it is important for readers to know exactly how many discrete surface samples these air-sea fluxes were calculated from if you later make the point that there was no difference between seasonal air-sea flux estimates from single biweekly samples, and continuous sensors (an interesting finding).

Response: We edited the text to clarify sampling frequency. It now reads, “However, we found no significant difference (within any season) between CO₂ flux values calculated with hourly sensor data versus single, discrete samples collected monthly to twice monthly (Table S2, Fig. 3).”

Line 531: add references of studies citing challenges with k parameterization

Response:

The following two references have been added:

- Borges, A.V., and G. Abril. 2011. 5.04 - Carbon Dioxide and Methane Dynamics in Estuaries. In *Treatise on Estuarine and Coastal Science*, ed. E. Wolanski and D. McLusky, 119-161. Waltham: Academic Press.
- Van Dam, B.R., J.B. Edson, and C. Tobias. 2019. Parameterizing Air-Water Gas Exchange in the Shallow, Microtidal New River Estuary. *Journal of Geophysical Research: Biogeosciences* 124: 2351-2363.

Lines 535-540: Yes, I agree these are some of the major sources of the challenge in determining air-sea fluxes, and I appreciate the inclusion of these additional datapoints on what fluxes might be if data were treated differently.

Anonymous Referee #2

Thank you for your careful consideration of and thoughtful responses to the reviewer comments. I think this revised manuscript is in much clearer, and the re-organization was helpful in terms of readability. I have a few additional minor comments, listed below.

Line 87 and 96: Define the acronym ASC at the first mention of Aransas Ship Channel (line 87, instead of line 96)

Response: Thank you for catching this. It has been fixed.

Line 328: Missing (before “Table S1)”.

Response: Fixed.

Line 349: The spring continuous data that differs in sign from the discrete data has a tremendous SD. Were there outliers in the data that could be removed to improve this stat?

Response: This opposite sign was not over the same time period; it is noted in the text that the negative spring flux from discrete data is for the entire 5+ years of monitoring (while continuous data only spanned 10 months). The sign difference between methods that is reported is likely indicating that the continuous period was not representative of the longer 5+ years of monitoring. The spring flux from discrete data during only the continuous monitoring period had the same sign as the continuous data (Table S1), and the two were not significantly different (Table S2).

While there is a large standard deviation, that is also the case for the continuous data during other seasons (Table S1), and there do not seem to be any visually egregious outliers in the continuous spring fluxes (Figure 3A). Removal of $p\text{CO}_2$ outliers was already conducted prior to flux calculations (Figures S2 and S3). Additional differences between methods could likely be due to sampling bias of the discrete data (continuous data captures more variability in $p\text{CO}_2$) and the different ways in which windspeed data were aggregated (the use of mean hourly wind speeds would allow for much more drastic flux values in the continuous data than the daily mean wind speed used for calculation with discrete sample data), which would naturally result in higher SD for fluxes calculated from continuous data. Individually pulling outliers would not likely improve this comparison.

Line 513: Which studies specifically? Would like to see citations here.

Response:

The following two references have been added:

Crosswell JR, Anderson IC, Stanhope JW, et al. Carbon budget of a shallow, lagoonal estuary: Transformations and source-sink dynamics along the river-estuary-ocean continuum. *Limnol Oceanogr.* 2017;62:S29-S45. doi:10.1002/lno.10631

Liu H, Zhang Q, Katul GG, Cole JJ, Chapin FS, MacIntyre S. Large CO₂ effluxes at night and during synoptic weather events significantly contribute to CO₂ emissions from a reservoir. *Environ Res Lett*. 2016;11(6):1-8. doi:10.1088/1748-9326/11/6/064001

Line 608: Specify which time scale – I believe you’re talking about seasonal here. Saying “on seasonal time scales” instead of “on certain time scales” would make the contrast with diel time scales (the following sentence) clearer.

Response: This has been fixed.

Line 712: I think it’s important to emphasize again that it supports the validity of long-term discrete sample collection, because short-term sampling would not capture interannual variability in the region.

Response: We have added a sentence to emphasize this: “Discrete data captured interannual variability, which could not be captured by the shorter-term continuous sensor data.”

Supplemental line 68: This mention of “buildup of respirational products” had me wondering about biofouling in the cooler – was there any evidence of biofouling, either in the cooler or on the submerged sensors, during the biweekly maintenance? Important to consider how this would impact measurements over time, if so.

Response: There was no evidence of biofouling within the cooler or on the Sami-CO₂ or SeaFET sensors within the cooler. This is the advantage of pumping the water from the surface of the ship channel into the cooler for measurements – the organisms did not survive that pumping process, but the water chemistry remained representative of the in situ surface waters. The YSIs that were deployed directly in the ship channel did experience some biofouling. We swapped them out every two weeks to make sure that biofouling didn’t get bad enough to influence the measurements.

Supplemental line 93: I believe this should be Table S6 instead of Table S5.

Response: Thank you for catching this. It has been fixed.

Supplemental lines 104-105: This is repetitive from the previous paragraph – potentially an editing error. Could include the discussion of offsets and SDs in the previous paragraph instead.

Response: This was an editing error. We have condensed text from these two paragraphs.

Something to consider: there is a lot of overlap between the results/discussion of the continuous and discrete samples, and including both types of data is a bit clunky at times. Because you make the point that long-term discrete sampling schemes capture interannual variability and are representative of the continuous sampling data, you could just focus on the discrete sampling set in your results/discussion where possible (seasonal variability and controlling factors). Diel variability results/discussion would focus on the continuous data, of course. This might improve

readability and remove excess length. There are some slight differences between continuous and discrete data, but since you conclude that discrete is representative of continuous, it would be okay to ignore those differences. This would necessitate a major revision, so it's just a suggestion.

Response: We appreciate this thoughtful suggestion. Due to the extensive nature of the edit and the exclusion of the few noted differences between methods, we decided to keep the continuous data in the results/discussion.